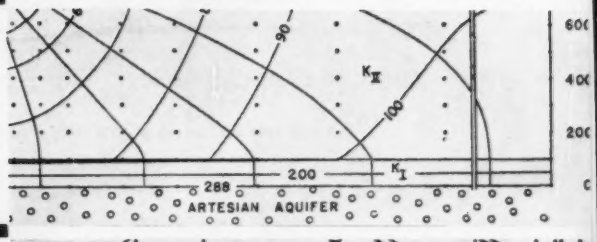
Development of a Fruit and Nut Harvester | 386

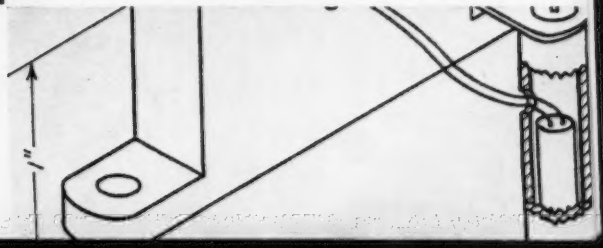
Automatic Unloader for Flat-Bottom Bins | 388

Soil Compaction by Traffic | 392

Unsaturated Flow in Drainage and Subirrigation | 395



Temperature Control with Thermocouples | 401



CASE HISTORIES

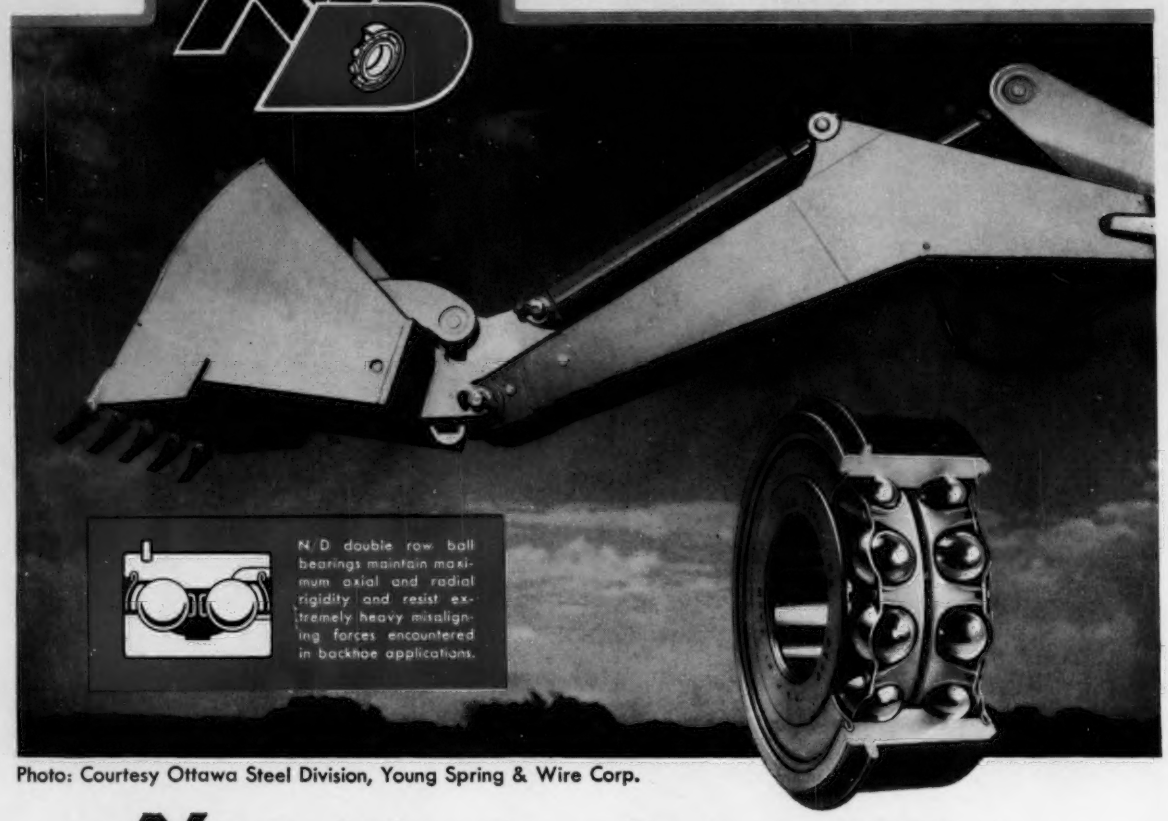

N/D double row ball bearings maintain maximum axial and radial rigidity and resist extremely heavy misaligning forces encountered in backhoe applications.

Photo: Courtesy Ottawa Steel Division, Young Spring & Wire Corp.

N/D Ball Bearings Reduce Friction... Up Usable Hydraulic Power In Backhoe!

CUSTOMER PROBLEM:

Increase efficiency of tractor/truck-mounted backhoe and reduce in-the-field maintenance requirements for the end customer.

SOLUTION:

N/D Sales Engineer, working with the manufacturer, recommended replacing 10 bronze bushings with factory lubricated New Departure shielded ball bearings. These New Departures eliminated arm play and loose joints . . . reduced friction to make more, useful hydraulic power available! What's more, shielded N/D ball bearings resist wear. They eliminated the need for relubrication maintenance because they're lubricated for life!

If you're working on new equipment designs, or redesigning, why not call on New Departure? New Departure's wide selection of construction and farm equipment ball bearings means there's probably a production bearing that will help you. For more information, write Department E-7.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Husk or shell... switch in less than 10 minutes! The No. 10 sheller attachment clean-shells bumper crops at fastest picking speeds... *stays* on when you husk. All bearings are life lubricated!

New Farmall® Six... famous 2-MH

make clean, big-yield picking easier than ever!

Harvest 20 acres a day with the 5-plow Farmall 560 tractor and 2-row McCormick 2-MH picker. Crib up to 8 extra bushels an acre with job-matched picking and husking rolls, separate husking bed, shelled corn saver.

Now, breeze through 100-bushel-plus yields with a great McCormick® 2-MH corn picker mounted on a super-smooth, new 6-cylinder Farmall 460 or 560 tractor. Big power, plus traction that puts it to better use, maintains picking efficiency in *all* conditions.

You change picking speed on-the-go with Torque Amplifier! You slow down to 1½ mph to clean-pick storm-flattened stalks. You *instantly* adjust snapping roll spacing on-the-go, to save more corn in abnormal field conditions. Completely independent pto helps you avoid down time due to slugging. And IH power steering ends "wheel fight" even in roughest fields.

Just drive in to mount the McCormick 2-MH picker on a new Farmall 460 or 560, or an older 3 or 4-plow model. Nineteen sealed bearings, and the Centralized Lubrication System—which lets you grease 80 others on-the-go—eliminate get-ready delay.

See Your...

INTERNATIONAL HARVESTER dealer

International Harvester Products *pay for themselves in use*—Farm Tractors and Equipment... Twine... Commercial Wheel Tractors... Motor Trucks... Construction Equipment—General Office, Chicago 1, Illinois

Agricultural Engineering

Established 1920

CONTENTS • JULY, 1959 • Vol. 40, No. 7

Report to Readers 376

Engineering in Agriculture 385
E. G. McKibben

Development of a Fruit and Nut Harvester 386
R. B. Fridley and P. A. Adrian

Automatic Unloader for Flat-Bottom Bins 388
H. B. Puckett

Soil Compaction by Traffic 392
William R. Gill

Theoretical Aspects of Unsaturated Flow in Drainage and Subirrigation 395
Herman Bouwer

Precise Temperature Control with Thermocouples . . . 401
J. L. Thames and S. J. Ursic

ASAE Officers, Council, Divisions, Representatives, Committees 403

News Section 407

ASAE Members in the News 408

Technical Paper Abstracts 416

Personnel Service Bulletin 422

New Books 423

Index to Advertisers 424

Note: AGRICULTURAL ENGINEERING is regularly indexed by Engineering Index and by Agricultural Index. Volumes of AGRICULTURAL ENGINEERING, in microfilm, are available (beginning with Vol. 32, 1951), and inquiries concerning purchase should be directed to University Microfilms, 313 North First Street, Ann Arbor, Michigan.

AGRICULTURAL ENGINEERING is owned and published monthly by the American Society of Agricultural Engineers. Editorial, subscription and advertising departments are at the central office of the Society, 420 Main St., St. Joseph, Mich. (Telephone: YUkon 3-2700).

JAMES BASSELMAN, *Editor and Publisher*

OFFICERS AND COUNCIL

American Society of Agricultural Engineers

L. H. Skromme, *President*

L. W. Hurlbut, *President-Elect*

Vice-Presidents	*Councilors*	*Past-Presidents*
E. W. Schroeder	A. W. Cooper	E. G. McKibben
J. W. Borden	H. H. Nuernberger	Earl D. Anderson
W. J. Ridout, Jr.	G. E. Henderson	

Jimmy L. Butt, *Executive Secretary*

Ralph A. Palmer, *Treasurer and Assistant Secretary*

Central Office: 420 Main Street, St. Joseph, Michigan

SUBSCRIPTION PRICE: $8.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $4.00 a year. Single copies (current), 80 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

The American Society of Agricultural Engineers is not responsible for statements and opinions advanced in its meetings or printed in its publications; they represent the views of the individuals to whom they are credited and are not binding on the society as a whole.

TITLE: The title AGRICULTURAL ENGINEERING is registered in the United States Patent Office.

COPYRIGHT: Copyright, 1959, by the American Society of Agricultural Engineers.

Reprints may be made from this publication on condition that full credit be given AGRICULTURAL ENGINEERING and the author, and that date of publication be stated.

AGRICULTURAL ENGINEERING is a member of the Audit Bureau of Circulations.

Mr. "Agricultural Engineering" Leaves ASAE Office

RAYMOND OLNEY, following 38 years of continuous employment with the central office of the American Society of Agricultural Engineers in St. Joseph, Michigan, retired as a regular member of the staff on July 1.

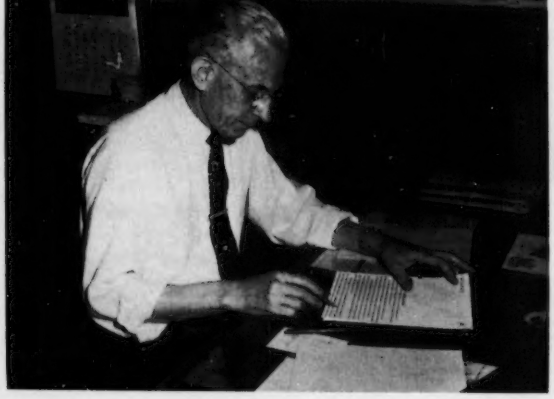
Mr. Olney became editor and publisher of AGRICULTURAL ENGINEERING, beginning with its fifth issue in January, 1921, and in November of the same year was appointed secretary of the Society. He brought to this work a background of familiarity with the Society's problems gained in service as its president in 1919. In 1922 he was elected treasurer and served continuously in that office until 1956. He retired as secretary of the Society in 1953 and as editor and publisher of Society publications in 1956.

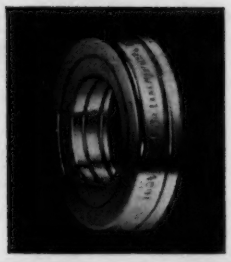
For the past three years Mr. Olney has been serving the Society's central office staff as counselor and as advertising manager of the organization's monthly journal and yearbook. For the time being he will continue to handle certain special assignments for the office.

In the wide range of work represented by the combined titles of secretary, treasurer, editor, publisher and advertising manager for over 30 years, his favorite task was that of meeting deadlines for the Society's publications. Ray was a member of the governing Council when the Society felt keenly the need to publish something more than its annual "Transactions." When the Council decided to inaugurate a monthly journal, it was Ray Olney who proposed and encouraged adoption of the name AGRICULTURAL ENGINEERING. Had it not been for Ray's recognition of the value of a short name, it, in all probability, would have been blessed with a most technical sounding name beginning with "The Journal of . . ."

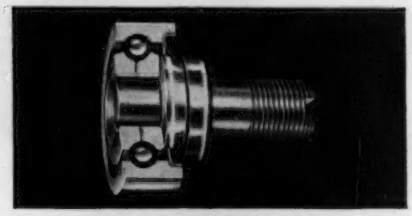
Ray could hardly have known during the Council sessions in 1920, that the next three or four decades of his life were being charted. Before one year had gone by, the new journal, which needed professional direction, had been turned over to him. At the time he was editor of "Power Farming," published in St. Joseph, Michigan.

Mere words cannot express the appreciation due Ray Olney for his unselfish devotion which has contributed so much to the growth and success of ASAE. Best wishes and many thanks, Mr. Agricultural Engineering!

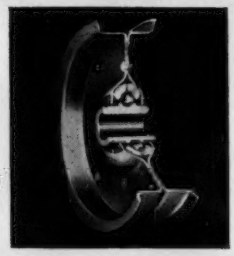




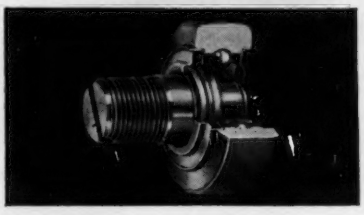
Clutch Bearings



Hay Rake Bearings



Idler Pulley Assemblies



Plunger Rollers

PIONEERING EXPERIENCE PAYS OFF FOR YOU . . . WHEN YOU USE BALL BEARING "PACKAGE UNITS" FROM BCA

You simplify production line installation and reduce manufacturing costs with "package units" designed and produced by BCA—the company that conceived and developed the ball bearing "package unit" idea. Bearing, housing and seal are combined in one rugged unit lubricated for life and sealed against water, dust and grit. BCA "package units" are available for a very wide range of applications including hay rake bearings, idler pulley assemblies, clutch bearings and plunger rollers. Count on BCA experience to provide ball bearing "package units" that are right for you and your customers . . . whether the application is unusual or routine. Bearings Company of America Division, Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

BCA BALL BEARINGS

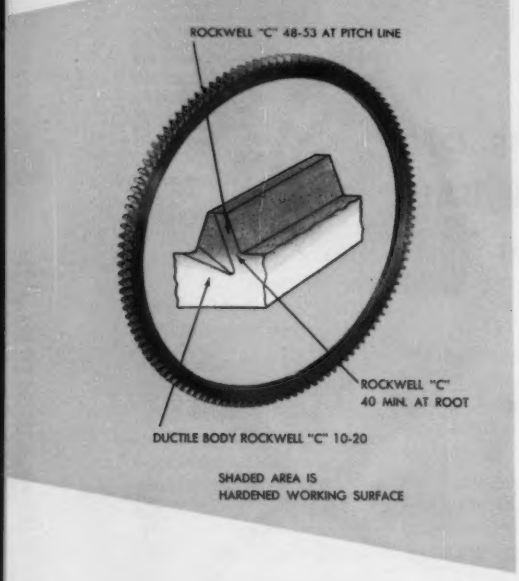
BEARINGS COMPANY OF AMERICA
DIVISION OF
Federal-Mogul-Bower Bearings, Inc.

To the Outboard Motor Industry

on its

GOLDEN JUBILEE

At the end of its first half century the outdoor motor industry can regard its "family of fans" with pride—all 35,000,000 of them. Today almost 25% of this nation's population find fun, recreation, even employment in outboard powered craft.



DOUBLE DIAMOND'S CONTRIBUTION

Major makers of electric-starting outboards come to Automotive Gear for their flywheel starter gear requirements. They receive our extensive experience in making millions of them for the automotive field—plus skilled engineering aid—plus respect for their specifications—plus localized hardening for better, longer gear performance—plus good delivery.

If you are powering a product, why not talk to the company that specializes in power transmission via gears of many types? An engineer will respond to your inquiry.

EATON

AUTOMOTIVE GEAR DIVISION
MANUFACTURING COMPANY
RICHMOND, INDIANA

GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

NATIONAL OIL SEAL LOGBOOK

Oil Seal Selector Chart

The data given below indicate, for most common applications, the type of oil seal that will operate best under given conditions. Where one or more parameters are extreme, modified or special seals may be required. For engineering help or availability details, call the nearest National Seal Engineer. Look under Oil Seals, in the Yellow Pages.

50,000 series
Micro-Torc
Leather

450,000 series
Syntech
Synthetic

410,000 series
Syntech
Synthetic

MATERIAL SEALED	Mineral base oils and greases are most common materials. Availability of lubricant, criticalness of service, and cleanliness strongly influence construction choice. National Micro-Torc leather seals are recommended for grease and oil applications and particularly where semi-starved lubricant conditions may exist. For oil and fluid "zero leakage" service Syntech seals are normally considered. For applications involving both "zero leakage" and heavy dirt conditions, the user may wish to consider dual lip Syntech seals.			
SHAFT SPEED	Prime factor in seal selection. Governs all other factors. Shown in FEET PER MINUTE AS SLOW, MODERATE, HIGH.			
FPM	Slow	0 to 800	0 to 1000	0 to 1000
	Moderate	800 to 1500	1000 to 2000	1000 to 2000
	High	1500 to 2000	2000 to 3000	2000 to 3000
TEMPERATURE	Limits shown are points where sealing material or medium sealed becomes ineffective. For sealing under extreme temperature conditions, special compounds can be employed.			
LIMITS °F.	Continuous	−65° +200°	−65° +225°	−65° +225°
	Intermittent	−65° +225°	−60° +250°	−60° +250°
PRESSURE	Conventional oil seals are not pressure seals. Where pressures above those shown exist, special seals should be employed or pressure against sealing lip relieved.			
MAXIMUM PSI	Slow	15	10	10
	Moderate	10	7	7
	High	5	5	5
SHAFT FINISH	Fineness and type of finish, direction and spiral of finishing marks and leads as well as RMS value affect sealing. Polished or ground finishes with concentric finish marks are preferred.			
MAXIMUM MICRO INCHES	Slow	25	25	25
	Moderate	20	20	20
	High	20	20	20
SHAFT HARDNESS	Although shafts as soft as cold rolled steel can be sealed successfully, hardness of C20 Rockwell or greater is preferred. Fluid starvation, abrasives and high surface speeds require hard shafts.			
SUGGESTED ROCKWELL	Abrasives	above C-45	above C-45	above C-45
	No abrasives	above B-80	above B-80	above B-80
SHAFT TO BORE MISALIGNMENT	Fixed misalignment of center of shaft rotation with bore center. Concentrates wear at one side of seal. Becomes more severe as speed increases.			
TOTAL INDICATOR	Slow	.010	.015	.015
	Moderate	.005	.010	.010
	High	.005	.010	.010
SHAFT RUN-OUT	Oscillating non-concentricity between shaft and bore centers (also eccentricity or shaft whip). Run-out should be kept to absolute minimum; creates difficult sealing problem.			
TOTAL INDICATOR RPM	0-800	.010	.025	.025
	800-2200	.005	.020	.020
	2200-4200	.003	.015	.015

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Redwood City and Downey, California
Van Wert, Ohio

8206

The switch is on to Greater Profits..

with **JOHN DEERE COMBINES**

More and more grain growers are switching over to John Deere Combines—and for some pretty good dollars-and-cents reasons. These growers compared their combine with their neighbors' John Deere. They noticed the John Deere moved along a little faster . . . that it handled higher yields and larger volumes of straw . . . that they just naturally saved more grain . . . and that the grain was always just a little bit cleaner. They looked, they compared—and they bought a John Deere.

There are many reasons why each John Deere Combine is the leader in its class. First of all, every John Deere Combine—and there are five models from 7 to 18 feet—has tremendous capacity in the cutting, threshing, separating, and cleaning units—enough extra capacity to handle anything that comes its way. But size alone is just part of the John Deere Combine story. Each unit is in perfect balance, each compliments the others to maintain an even flow of material from the moment the grain is cut 'til the straw is discharged and the grain is augered into the tank. That's why a John Deere

John Deere 16- or 18-foot 95 Self-Propelleds harvest up to 3000 bushels per day and bring harvesting time and costs to brand-new lows.

moves along at a faster pace, why it saves more grain and delivers a cleaner sample to the tank. It's why owners bin more bushels, bank more dollars with a John Deere.

This complete line of quality-built combines is why the big switch is on to greater grain profits, and it's another reason why the John Deere franchise is the most valued in the farm equipment field.

JOHN DEERE
MOLINE, ILLINOIS

Wherever crops grow . . . there's a growing demand for John Deere Farm Equipment

Report to Readers . . .

ENGINEERS DEVELOP AXIALLY FLEXIBLE SCREW CONVEYOR FOR GRAIN HANDLING

A research study is under way by Cornell agricultural engineers to develop an axially-flexible conveyor for handling grain. This new conveyor will combine much of the flexibility of the pneumatic conveyor and the positive movement and comparative dustless operation of an auger. The principal problems being studied have to do with the form and construction of the screw and the construction of the carrier tube. Two different types of construction have been chosen for experimental purposes. . . . . The first model will be 6 inches in diameter and 10 feet long. The screw will be formed by fastening a series of 5-inch spiral sections to a flexible shaft. The tube is similar to flexible exhaust tubing. . . . . The second model will use the same type shaft and tubing, but the screw will be formed of concentric wire spirals fastened at intervals to the center shaft. This allows use of a continuous screw but still provides flexibility. This conveyor is expected to have operating characteristics similar to the standard screw conveyor, and it is believed the flexible auger can be developed into a feasible piece of standard farm equipment.

TEST REPORT OF DRY-TYPE AIR CLEANERS FOR FARM TRACTORS

After two years of testing automotive dry-type air cleaners, Illinois AES agricultural engineers have concluded that their performance is not good enough to replace the oil-bath cleaners now used on farm tractors. While the dust-separating efficiency of the dry-type cleaner proved satisfactory in the laboratory, this did not hold true in the field tests. . . . . The Illinois engineers report that the only use they can now recommend for the dry-type cleaner on tractors is as a precleaner mounted above the oil-bath cleaner. This has the advantage of greatly reducing regular oil changes and eliminating the problem of chaff in the oil-bath cleaner. . . . . Manufacturers are cooperating with the Illinois engineers in testing designs of dry-type cleaners with a view to ultimately finding one that will prove satisfactory and offer the practical advantages of this type of cleaner.

AG ENGINEERS INVESTIGATE HAY-IN-A-DAY HARVESTING

In a research study made by Michigan AES agricultural engineers, it was found possible, on a good drying day, to harvest and store alfalfa hay yielding 7+ tons per acre (with moisture content reduced to 20 percent) within 6 hours after cutting. To achieve this result, two requirements were necessary. The fresh-cut alfalfa first had to be "hard crushed," that is, the stem surface nearly disintegrated. For this purpose use was made of a laboratory-model crusher consisting of two cylindrical rollers with smooth surfaces, and with a clearance of less than 0.015 inch between the rollers. The second requirement was to provide a vapor barrier between the moist ground and the hay. Black polyethylene proved to be the most suitable material for such use. . . . . The researchers report that the results of their study indicate that hay mowed before 10:00 a.m., "hard crushed," and placed on black polyethylene sheets, will dry to a storable moisture content of 20 percent before 4:00 p.m., and may be harvested the same day.

SELF-PROPELLED MACHINE CLEANS POULTRY HOUSES

A manure pickup device has been designed by California AES agricultural engineers for use in obstruction-free areas under strings of wire-mesh poultry laying cages that appears to have high efficiency. The machine is self-propelled and capable of picking up 1/2 cubic yard of poultry manure in 3 to 4 minutes. It has a 9-inch-diameter auger with a floor-scraping shroud, which picks up the manure that has accumulated in a windrow under the cages and conveys it into a paddle elevator. It is then raised to the top of the machine and thrown by centrifugal force into a bucket.

(Continued on page 378)

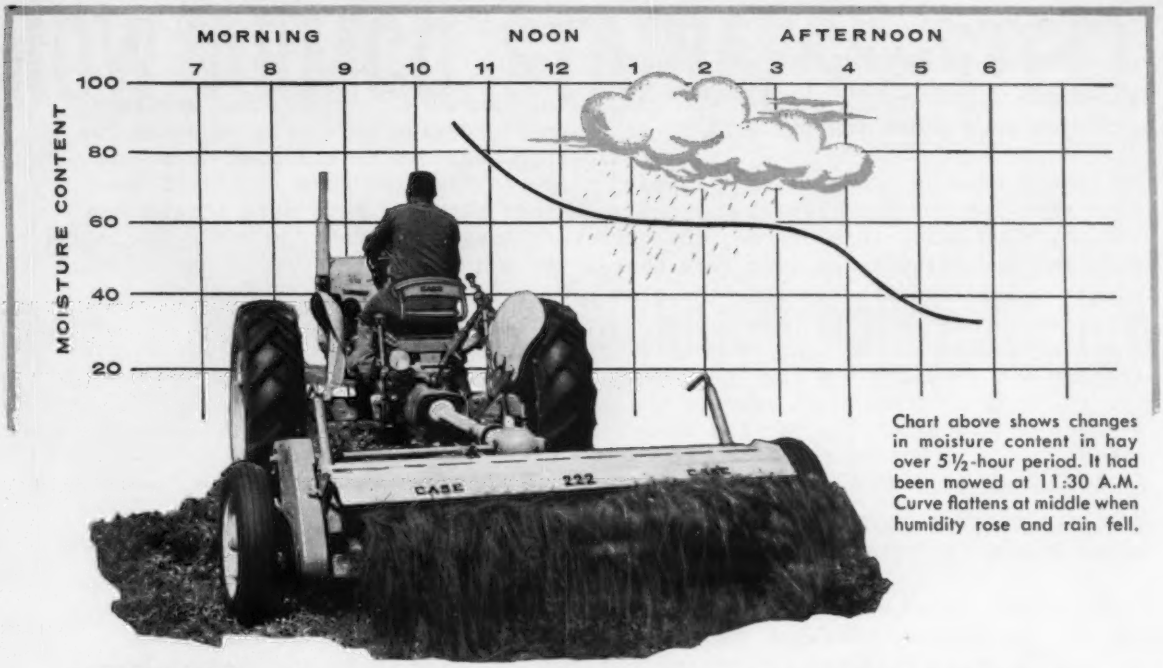


Chart above shows changes in moisture content in hay over 5½-hour period. It had been mowed at 11:30 A.M. Curve flattens at middle when humidity rose and rain fell.

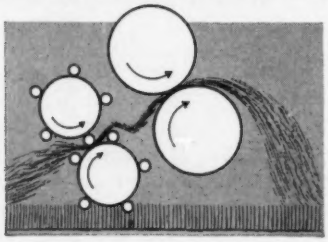
CASE. hay conditioner engineers *WELCOMED* an unexpected shower!

It started as a routine test. Case engineers were measuring the crimping *and* crushing efficiency of the new Case 222 hay conditioner . . . in relation to conditioners that crimp *or* crush only. At 11:30 A.M. the hay was mowed, and immediately conditioned. Moisture checks were taken at hourly intervals . . . of both hay conditioned with the Case 222 conditioner and with competitive machines.

Shortly after 1:00 P.M., the humidity rose. At 1:40 P.M. a light shower passed over.

Should the test be cancelled? No . . . Case engineers saw a real opportunity. Every day, farmers were experiencing the same unexpected showers during *their* hay making.

Regular moisture checks were continued. The final check at 5:00 P.M. gave the answer! *In spite of the shower*, the hay conditioned with the Case 222 was ready for baling and modern mow drying . . . 5½ hours after cutting. The next best sample (from other machines tested) showed a 6% higher moisture content . . . making it necessary to hold off baling until the following day.



Here's how CASE 2-way conditioning works

The pick-up rolls lift hay cleanly and gently without shattering leaves . . . round bars welded to pick-up rolls break each stem to relieve moisture. Hay is then force-fed to crushing rolls which split each stem so drying begins immediately. Hay is then deposited back on the ground in fluffy, fast-drying swaths.

Modern engineering for modern farming is more than just a phrase at Case . . . it is a philosophy . . . a perpetual dissatisfaction with old, outworn concepts . . . a constant seeking of new concepts in power farming—of new approaches to the basic problem of producing more for less.

J. I. CASE

J. I. CASE CO. • RACINE, WIS.

1st in Quality for Over 100 Years

. . . Report to Readers (Continued from page 376)

AUTOMATIC PILOT STEERS TRACTOR — OPERATOR GOES ALONG FOR THE RIDE

A USDA agricultural engineer has designed an automatic device primarily intended for "piloting" tractors up and down corn rows. It should prove a great boon to farmers since cultivating corn is one of the most exacting and monotonous steering jobs they normally have with tractors. . . . . When using this device, the operator lines the tractor up with the proper row, and the pilot takes over from there. At the end of the row the operator simply guides the tractor into the next row. . . . . The pilot was specially designed for use with hydraulic power steering. The automatic feature includes a set of feelers which hang from an electric swinging unit on the front of the tractor and straddle the row, automatically keeping the tractor on the row. . . . . This device should improve the accuracy of cultivating, with less injury to crop and less fatigue for the operator, and with possibly increased cultivating speeds. . . . . Future research studies on this pilot will be directed to adapting it to cultivating small plants 2 to 3 inches high, such as corn and soybeans.

NEBRASKA TRACTOR TESTING LABORATORY MAKES CHANGE IN ITS TEST PROCEDURE

In testing tractors heretofore at the NTTL, the manual throttle-control lever of the tractor was adjusted to maintain rated engine speed when the tractor was operated at 75 percent load. It is now set to maintain the same speed with the tractor operating at full load. . . . . Corrected figures for horsepower have for many years appeared in Nebraska test reports. However, it was found that the corrective factor formerly in use could not be applied to some tractors with certain types of transmissions. For that reason, no mention is to be made of "corrected horsepower" in future test reports. . . . . Also, the term "rated horsepower" will no longer be used because of conflicting ideas as to its meaning. Fuel consumption tests are now being run at 100, 75 and 50 percent of the pull at maximum power.

NEW SEED-POTATO CUTTER CAN CUT 15,000 PIECES AN HOUR

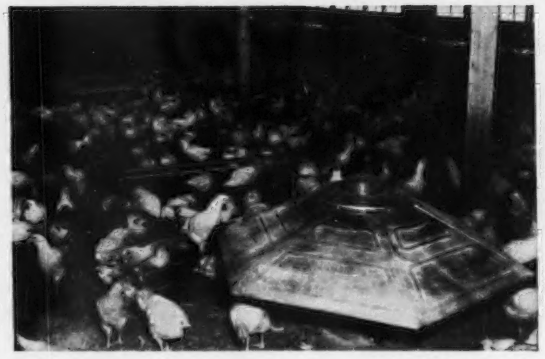
A USDA agricultural engineer has designed an experimental seed-potato cutter that under test has cut some 15,000 pieces an hour. This is about enough to plant one acre, depending on row and seedpiece spacings. It is estimated that one operator hand-feeding a commercial cutter based on this model could equal the output of four to five workers cutting by hand. . . . . This cutter has a rotary table fitted with positioning mechanisms for four potatoes. The potatoes are placed in two positioning mechanisms at a time. By turning the table 90 degrees, the first potato is placed under a plunger, which pushes the potato half way through a knife having three radiating blades. A rotating horizontal knife halves the potatoes lengthwise, dropping the first three seed pieces to a conveyor. Rotating the table another quarter-turn places the remaining half potato under a second plunger that pushes the piece through a second vertical three-bladed knife. Two positions on the rotary table are always open for feeding.

RIGHT-ANGLE TILE JOINTS RESULT IN LOWER-COST DRAINAGE SYSTEMS

Old idea was that a lateral had to be connected to a main tile drainage line at a 45-deg. angle for best results. However, a team of USDA-Minnesota AES agricultural engineers has found in tests of model systems at the St. Anthony Falls Hydraulic Laboratory, Minneapolis, that right-angle tile joints will perform just as well. . . . . The big advantage of this to farmers is that, by using 90-deg. joints, it will considerably reduce the cost of installing the hundreds of millions of feet of draintile on farms each year. Reason is that 45-deg. junctions require more hand labor and other installation expense, and because of difficulty in fitting, poor connections often result. Another thing, laterals generally have to be curved to connect with the main line at that angle. . . . . Other junction angles, from 15 to 165 deg., were tested, but were found to have no advantage over the 90-deg. angle.

HOW ARMCO STAINLESS STEEL helps balance chicken-brooder design

Burner parts made of Armco Stainless Steel help provide balanced design in chicken brooders.



New steels are born at Armco

In agricultural equipment farmers want dependable service from *every part* . . . regardless of the severity of operating conditions. This is why Brower Manufacturing Company, Quincy, Illinois, designed Armco 17 (Type 430) Stainless Steel into the burners of their Kero-Gas Brooders.

These brooders are fired by evaporating kerosene that puts the flame directly in contact with the stainless steel burner screens. "As you can well imagine, these screens get red-hot while in use, so we need a material that will stand up," states a Brower official.

Many Grades

Whatever *your* design problem, chances are that you can find the solution with one of Armco's Special-Purpose Steels. Besides a vast array of stainless grades, Armco produces special coated steels and coated welded steel tubing. For suggestions in material selection, just write Marketing Service Department, Armco Steel Corporation, 2739 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

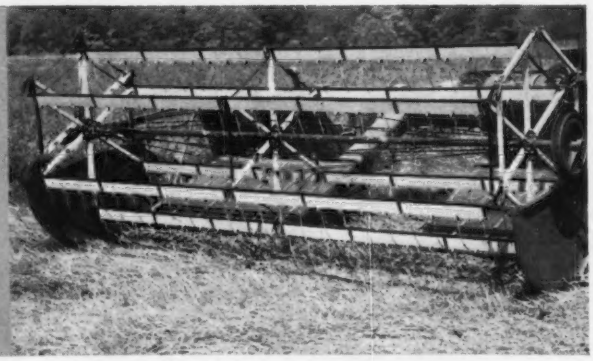
let us help you solve this problem

A pick-up type reel is an important contribution to the performance of any harvester — and the design of the right harvester-matched reel is a specialized problem. Why not employ our engineering skill and background to help in this important phase of your overall harvester design? Drawing on our experience of over 25 years and many exclusive patents, we can engineer a pick-up reel tailored to the other design characteristics of your machine, and the crops and areas being served. As a leading producer of pick-up reels, we have the plant capacity and automated production lines to assure you of delivery at reasonable costs. Let us conserve your valuable engineering time.

Also designers and manufacturers of harvesting machines for green peas, spinach, lima beans, mint, greens, pumpkins and other specialized crops.

H. D. HUME COMPANY
Mendota, Illinois

HUME



SAVE with Aetna BEARINGS

DO YOU HAVE THE NEW AETNA GENERAL CATALOG AND ENGINEERING MANUAL?

Contains valuable engineering data, formulas, tables, design application drawings, shaft and housing fits, lubrication helps, etc. in a compact, readily accessible unit.

Secure your copy by phoning your local representative listed in your Classified Phone Book or write direct.

SAVE design adjustments and compromises

The Aetna line of quality precision bearings is so complete and diversified that within it there is undoubtedly the exact bearing, with the exact specifications, required for your design. No need to modify or change your design—no need to specify characteristics which require extra-cost handling.

This is especially true of Thrust Bearings—a field in which Aetna is the acknowledged leader—with a broad line of sizes and load ratings to meet practically all requirements from stock.

SAVE assembly costs

Precision dimensions held to exact tolerances guarantee press fit without effort or adjustment. Bearings received in perfect, factory-fresh condition, require no cleaning—no checking or inspection. Simply remove from carton, strip off the protective wrapper and install.

SAVE repair and replacement losses

Aetna bearings stand up under the loads and service for which they are designed—give long hours of perfect anti-friction performance—require no attention beyond periodic lubrication—seal out dirt, dust, grit and atmospheric impurities—and permit your equipment to deliver the fine, trouble-free performance which you have built into it.

AETNA BALL AND ROLLER BEARING COMPANY

DIVISION OF PARKERSBURGH-AETNA CORPORATION • **4600 SCHUBERT AVENUE** • **CHICAGO 39, ILL.**

Aetna **ANTI-FRICTION CONSULTANT TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916**

No corrosion worries when handling liquid fertilizers with Stainless Steel

In 1898, Sir William Crookes foresaw an "impending catastrophe" because wheat yields were not keeping up with the growing population. But, as Sir William also predicted, nitrogen fertilizers saved the day . . . and the population!

It took a lot of research and field tests to make handling of *liquid* complete fertilizers practical and profitable. A material had to be found that would hold up under the corrosive action of *every* type of liquid fertilizer.

Exhaustive laboratory and field tests showed that only Stainless Steel would give long, trouble-free service without the danger of corrosion and annoyance of clogging nozzles. United States Steel cooperated closely with liquid fertilizer manufacturers and tank fabricators to make the handling of liquid fertilizers a profitable and time-saving operation for farmers. If you would like information on metals for handling liquid fertilizers, write to United States Steel, Agricultural Extension, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

USS **United States Steel**

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

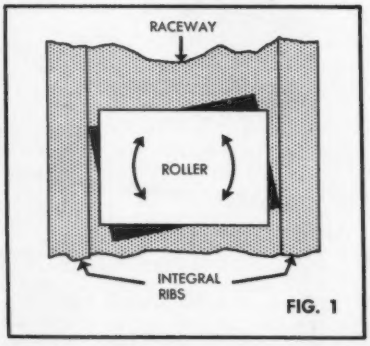
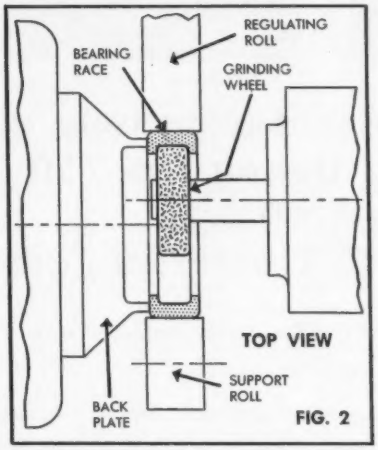
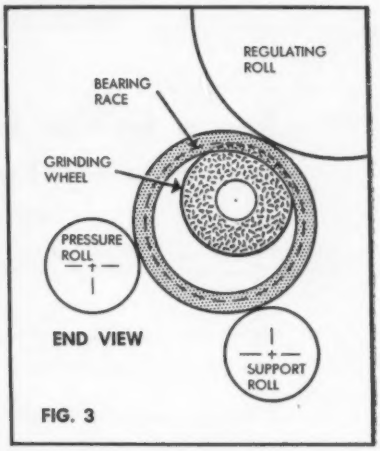


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.

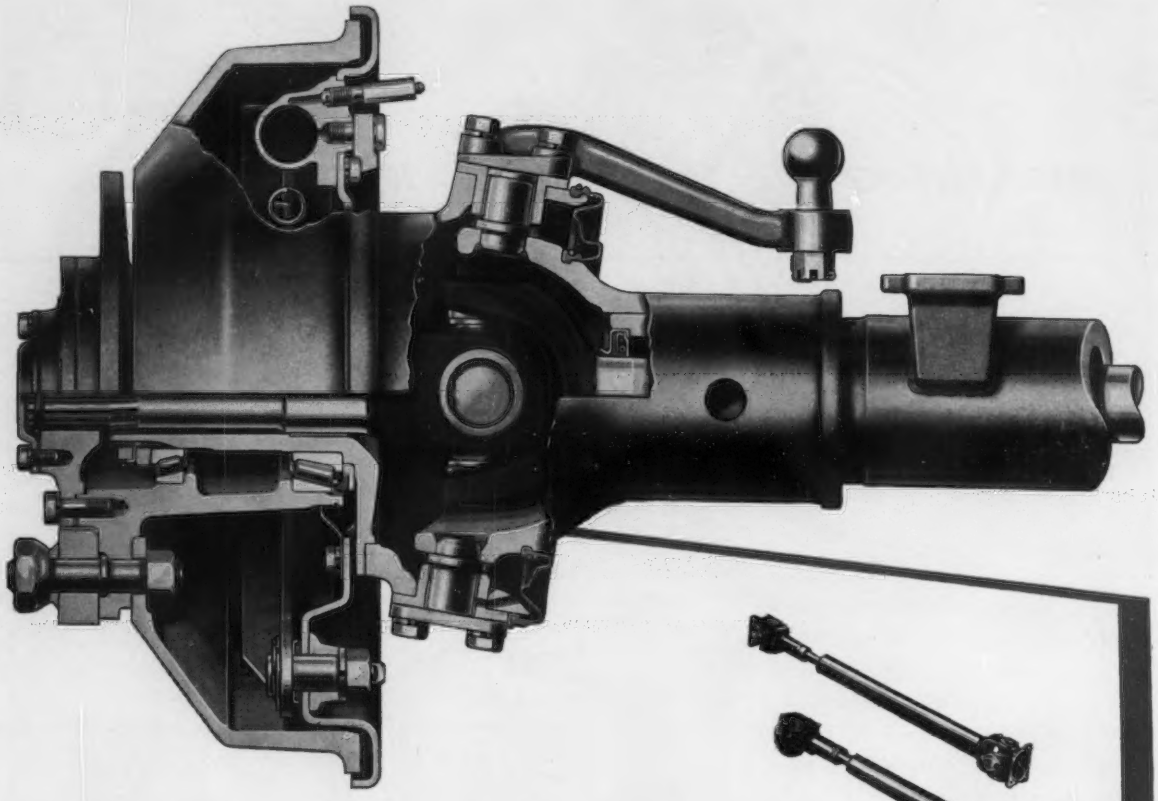


★ ★ ★ ★

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN



For a better front-driving axle, get this Timken-Detroit FDS-750

equipped with

BLOOD BROTHERS Universal Joints

Here's another example of Blood Brothers' engineering cooperation . . . to produce ever-better truck components.

When this major axle source wanted an improved front-driving unit for a truck-building customer, their engineers and ours got together. The result shown above now provides users of famous brand trucks with *substantially increased capacity* on their front-driving axles.

Greater strength, better performance and lower costs may result for your products too—through a cooperative effort with Blood Brothers.

Just write or call—we'll arrange to meet at your convenience.

For a quick review of our products, request Bulletin 557.

STANDARD PROPELLER SHAFT ASSEMBLIES

SINGLE AND DOUBLE JOINTS FOR POWER TAKE-OFF USE

CLOSE-COUPLED JOINTS AND ASSEMBLIES

ROCKWELL-STANDARD CORPORATION

Blood Brothers Universal Joints

ALLEGAN, MICHIGAN

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

Agricultural Engineering

July 1959
Number 7
Volume 40

James Basselman, *Editor*

ENGINEERING IN AGRICULTURE

DURING the past year it was my privilege to attend a dinner given by Engineers Joint Council for the presidents of its member societies, and along with the presidents of other sponsor societies to sit at the head table at the all-congress banquet of the 5th Nuclear Congress. At these and too many other occasions it has been necessary to explain, if not actually to justify, the term "agricultural engineering." This is in spite of the fact that outstanding agriculturalists (not engineers) have stated that more than 85 percent of farm problems involve engineering applications. Agricultural engineers believe this to be a conservative estimate, and that nearly all farm operations require engineering applications if they are to be most effective and economical.

It is not surprising, of course, that there are many who do not know about or even that there is an American Society of Agricultural Engineers. However, what really should concern us is the implied if not actually stated reaction that the term "agricultural engineering" is professional heresy, a semantic paradox, in fact, a blasphemous and even sacriligious use of the term "engineering." Such individuals either do not understand "engineering," or they do not know "agriculture," or both.

Perhaps this situation is best ignored. However, as retiring president of our Society, I believe agricultural engineers should be prepared to inform those who are so uninformed about "engineering" and/or "agriculture" as to feel that the combination of these two words in the term "agricultural engineering" is incongruous, unsuitable, unreasonable, or at least inappropriate.

Engineering

First, it should be noted that the designation of a branch of engineering by the group, activity, or industry served, is a well-established precedent. The first generally recognized group of engineers were called "military engineers." The first division of engineering into branches was "military" and "civil" engineering, engineers who served military and civilian activities, respectively. No one raises an eyebrow at the mention of "automotive engineering," or many other designations of engineering groups which serve particular activities or industries.

At this point it should be noted that continued outstanding accomplishments by agri-

Annual address of the President of the American Society of Agricultural Engineers before the 52nd annual meeting of the Society at Cornell University, Ithaca, N. Y., June 21-24, 1959.

Eugene G. McKibben

President of ASAE, 1958-59, and director, Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture

cultural engineers as individuals and as members of our professional society are, of course, the most important means of establishing a recognized standing for our branch of engineering. In the meantime, let us ask those who are shocked by the combination of the words "agriculture" and "engineering" in the term "agricultural engineering," what "engineering" is and what "agriculture" is and why they consider the combination not to be appropriate?

What is engineering? Many definitions have been given; books have been written on this subject. However, a brief definition recently used by a dean of an engineering school of a leading university is, in principle at least, generally accepted. He defined engineering as "the science and art of the utilization of materials, energy and men."

Agriculture — Materials

What is agriculture, from the standpoint of materials, energy and men, the major elements of engineering interest?

From the standpoint of problems dealing with the *utilization* of *materials*, American agriculture is a top engineering industry. Its equipment and construction needs require over six million tons of finished steel annually, more than enough for a year's output of passenger automobiles and more raw rubber than that required for these automobiles. The depreciated value of the machines and structures used in agricultural production is over 30 billion dollars. This is two to three times the net investment in the entire steel industry and more than five times the total investment in automobile manufacturing. The annual expenditure for maintenance, replacement and expansion of these facilities is between three and four billion dollars.

More than 40 million tons of chemical materials are required by each year's agricultural production. Irrigation for agricultural production uses averages more than 100 billion gallons of water per day, about half the fresh water used in the United States. More than 250 billion tons of soil are turned or stirred each year, much of it several times, by tillage and cultivating operations. This is probably the world's largest materials-handling operation. It is enough soil to make a ridge 100 feet high and one mile wide from New York to San Francisco.

Further, from the standpoint of the possibilities of engineering application of new materials, agriculture offers outstanding pioneering opportunities. New plastics, alloys, and chemicals are finding and will continue to find some of their most extensive and economic uses in agriculture. In fact, the needs and requirements of agriculture are so varied and severe that it is difficult to imagine any new construction material or new chemical compound which would not have an effective place in some agricultural machine, building, or operation. The list of such materials and uses is too long to give here and is becoming longer each day.

Finally, the production, which is the objective of the utilization of materials so far listed, presents both extensive and unusual engineering problems. American agriculture produces about 600 million tons of crop and animal products each year. This is more than five times the weight of the total annual steel production in the United States.

Agriculture—Energy

From the standpoint of *power*, the utilization of energy, agriculture is an equally important engineering industry. Over 95 percent of American farms have central line electric energy available. These farms are now using about 25 billion kilowatt-hours annually with each year showing a substantial increase.

The motor vehicles on our farms number about 12 million—3 million automobiles, over 4 million trucks, and over 4.5 million tractors. This includes about 8 percent of the national registration of automobiles and more than a fourth of the national registra-

(Continued on page 412)

Development of a Fruit and Nut Harvester

R. B. Fridley and P. A. Adrian
Assoc. Member ASAE

Engineers develop new pickup principle with two reels, one operating against and the other in the direction of travel

HARVESTING some fruits and nuts involves picking the fruit off the ground after it has fallen naturally or been shaken from the trees. Pickup by hand is both costly and slow. The uncertainties and costs of farm labor have led to many advances in machines that will pick up nuts from the ground. However, for various reasons, commercially manufactured machines have not proved completely satisfactory for the harvest of all fruits that can be allowed to fall to the ground.

In the light of this situation, a cooperative research project between the University of California and U.S. Department of Agriculture was initiated to develop a new pickup principle that would pick up fruit with positive action without disturbing the soil surface or damaging the fruit. The principle developed has now been accepted for manufacture.

Paper presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Asilomar Beach, Calif., February, 1959.

The authors—R. B. FRIDLEY and P. A. ADRIAN—are, respectively, assistant specialist in agricultural engineering, California Agricultural Experiment Station, and agricultural engineer (ARS), U.S. Department of Agriculture.

In general, pickup machines used up to the present have been either mechanical or vacuum-type devices. Mechanical devices seem to be the most practical since they can be made less complicated and require less power. For this reason, the principles applied in constructing various mechanical pickup machines were analyzed to determine their good and bad features. The analysis involved laboratory tests in which high-speed movies were taken of the pickup action of each principle. The units tested were all basically reel-type devices similar to a leaf-sweeper reel(1)*.

Studies of the high-speed movies revealed undesirable characteristics that it would have been impossible to observe on a machine in the field. The first observation was that reels, rotating with the direction of travel and gaged close to the ground, exert a downward component of force on the fruit since the fingers are traveling downward when they first come into contact with it. On the other hand, large reels rotating against the direction of travel, roll the fruit, developing a windrow in front of the reel. The windrow is the result of two things: *(a)* If the fingers of the reel are radial, they are nearly vertical at the time of contact with the fruit, and the force applied to the fruit is essentially horizontal in consequence. *(b)* If curved fingers are used in an effort to get a force applied to the fruit at a more desirable angle, there is appreciable interval during which the finger will contact only the top side of the fruit, rolling it ahead(2). In Fig. 1, it can be seen that the optimum time for contact between the finger and the fruit is during interval *a*. During the travel of the finger tip from A to B, contact with the fruit results in rolling the fruit. The percentage of fruit that is rolled can be reduced by increasing the ratio of *a* to *b*, which is achieved by decreasing the ratio of reel diameter to fruit diameter, *D*/*d* (Fig. 2). Fig. 1 also shows the angle θ—the angle of a finger with respect

*Numbers in parentheses refer to the appended references.

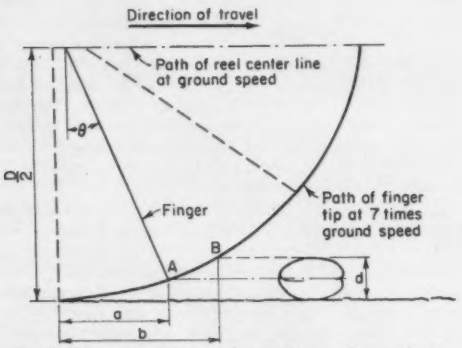


Fig. 1 Diagram of fruit pickup with a reel-type device

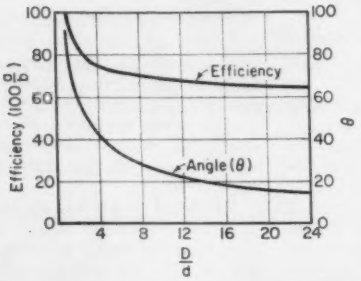


Fig. 2 Theoretical pickup performance as affected by the ratio of reel diameter to fruit diameter

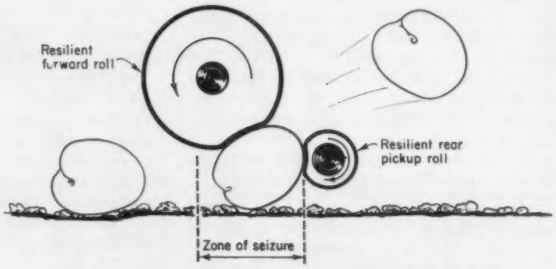


Fig. 3 The new pickup principle illustrated

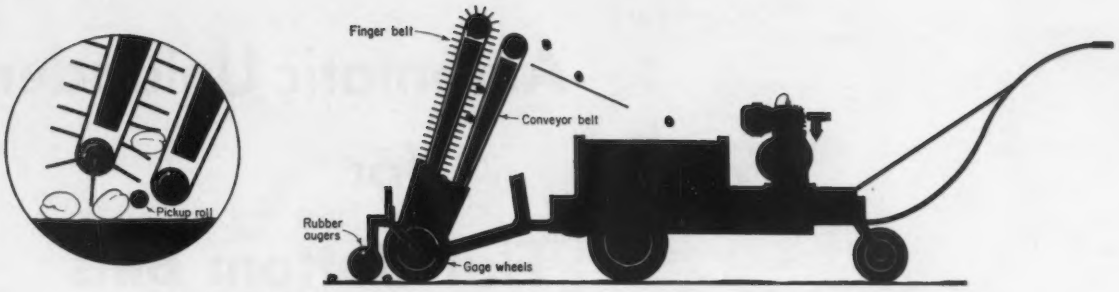


Fig. 4 Pickup principle incorporated with conveyor system • Fig. 5 Schematic of pickup harvester

to the perpendicular when the finger tip is at point A. From the geometry of the system, it can be seen that the angle θ is also the maximum slope possible for a desirable force application on the fruit for a certain size of reel. By increasing this angle, a smaller force is applied to the fruit for a given upward (lifting) component of force. This angle can be increased by decreasing the ratio D/d, as shown in Fig. 2.

New Principle

Fig. 2 shows that a reel diameter about equal to the fruit diameter would be the optimum desired. However, using a reel of diameter about equal to the fruit diameter results in an upward force being applied on one side of the fruit and not passing through the center of gravity of the fruit. To produce a resultant force passing upward through the center of gravity, a second reel must be placed above and in front of the first reel. Thus the new pickup principle (Fig. 3) consists of a small reel (or roll) that rotates against the direction of travel, and a second reel, above and in front of the first reel, that rotates in the opposite direction. The second reel is flexible so as to prevent damaging the fruit as it passes between the reels (or rolls).

The new principle, combined with an elevator system, is shown in Fig. 4. The finger belt, which serves in both pickup and elevation capacities, has rubber fingers 1¼ in. long, 3/16 in. in diameter and ½ in. apart. A wider spacing would be satisfactory. The pickup roll was constructed by slipping a ⅞-in. water hose over a ⅝-in. shaft. Power is supplied to the two belts through the top pulleys, and to the pickup roll through a ¼-in. pitch roller chain, using the idler pulley shaft of the rear conveyor belt as the driver.

The pickup head assembly is floated over the soil surface on the gage wheels (Fig. 5). To obtain optimum gaging on varying soil surfaces the head is partially counterbalanced through a spring-cam arrangement. The path of the gage wheels is cleared by rubber augers.

The pickup machine was initially designed for prunes (3). The average harvest rates and picking costs for prunes are shown in Figs. 6 and 7. The harvest rate shown for a three-foot swath represents an average, since it is appreciably affected by the availability of empty field boxes. The costs cover machine depreciation and labor only, excluding shaking the trees, hauling the fruit, and preparing the soil. The figures used for the cost determination are: $1,000 machine cost (depreciation over 5 years), $1.25 per hour labor cost, harvest rates at 1½ mph, and a yield of 8 green tons per acre.

One point that should be emphasized is the importance of preparing the ground. Although land preparation is not as critical with this unit as with most other machines, optimum performance requires it. Preparation consists of leveling out small ripples in the surface, filling in the holes, and rolling the ground to push the clods down. On a prepared surface, all fruit will be at substantially the same elevation (4) (Fig. 8).

In general, on properly prepared land, the new principle has the following advantages: *(a)* a positive pickup of the fruit as the machine moves into it, *(b)* only small impact force on the fruit, and *(c)* no soil disturbance by the pickup roll. Tests on walnuts, prunes, and figs indicate that the positive pickup and small impact force results in little or no fruit damage (Table 1). The positive pickup, in conjunc-

(Continued on page 391)

TABLE 1. COMPARISON OF RESULTS FOR DIFFERENT METHODS OF HARVEST ON FRENCH PRUNES

	Pickup by hand	New pickup principle	Existing pickup machines
Visual damage to fresh fruit	Negligible	Negligible	1 to 10 percent
Percent of dirt picked up in relation to percent of weight of fruit picked up	0.5	0.5 to 3	4 to 30
Fruit missed	Negligible	Negligible	Negligible

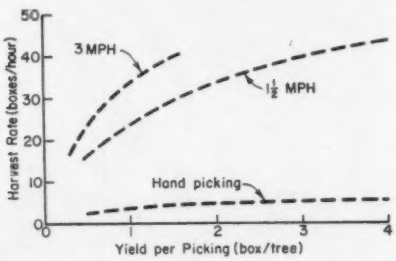


Fig. 6 Approximate harvest rate of three-foot swath machine

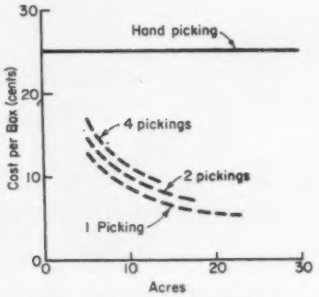


Fig. 7 Approximate harvest cost of pickup machine

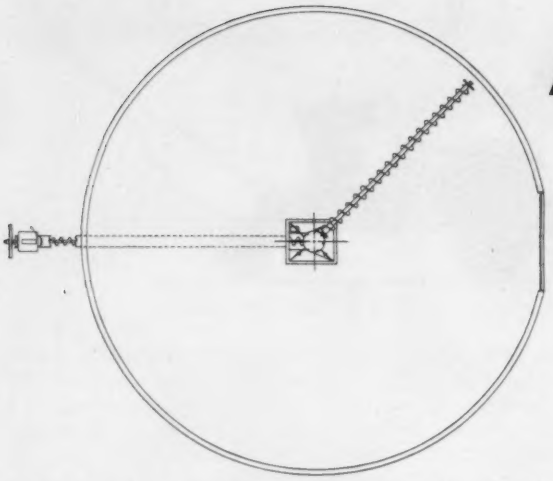


Fig. 1 Plan view of installed automatic flat-bottom bin unloader

Automatic Unloader for Flat-Bottom Bins

H. B. Puckett
Member ASAE

Almost complete unloading of flat-bottom bins accomplished by combining operation of a sweep auger with a discharge auger

THE search for a new-type unloader for flat-bottom bins was initiated because of the need for a dependable supply of feed material for an automatic feeding system. Hopper-bottom bins have been used to a large extent to store feed materials and supply them to the system. It is desirable to use gravity in an automatic system where possible. Hopper-bottom bins utilize gravity for unloading, but usually represent a higher cost per bushel of storage than do other types of bins. This is acknowledged and is accepted because material is available at a single point for convenient withdrawal.

Paper presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1957, on a program arranged by the Electric Power and Processing Division.

The author—H. B. PUCKETT—is agricultural engineer, farm electrification research laboratory (AERD, ARS), U.S. Department of Agriculture.

AUTHOR'S NOTE: This paper reports results of cooperative research between the USDA farm electrification research laboratory, the agricultural engineering department of the University of Illinois, and the Illinois Farm Electrification Council.

Fig. 2 The sweep auger rotates in a horizontal plane above the bin floor and will undercut caked material

A problem with gravity-powered systems, such as the hopper-bottom bin, is that although bridging can be minimized and made improbable, it cannot be entirely eliminated. The probability of bridging in a material supply bin must be considered in the design of an automatic feeding system. It is apparent that the hopper-bottom bin is not the last word in feed storage. It also seems quite probable that flat-bottom storage will be used for a long time. Many farmers who would be interested in installing automatic feed-handling systems are hesitant to discard flat-bottom storage and construct hopper-bottom storage in its place. There are two reasons for this: First, the hopper-bottom storage costs more, and, second, and less important, is that they reduce the possible storage space.

If an unloader could be provided for flat-bottom storage as it is presently used, and at a cost not exceeding the difference between the flat-bottom storage and an equivalent hopper-bottom storage, it would work well into an automatic feed-handling system. While there are several mechanical unloaders for flat-bottom storage, they require some manual labor to remove the last several feet of stored material. This may consist of moving the conveyor and scooping material by hand. The mechanical unloader which we have developed will almost completely unload a flat-bottom bin without manual attention. If the stored material can be conveyed by an auger, the unloader will remove it from the bin and deposit it in another conveyor or conveyance at the outside of the bin.

The unloader consists of two augers: a sweep auger to gather the material from the sides of the storage and deliver it to a small hopper in the center of the bin and a discharge auger to remove the material in the center hopper to the outside of the bin for deposit in another conveyor (Fig. 1). The sweep auger is the unique addition to an otherwise ordinary auger unloader. It is an open auger pivoted in the

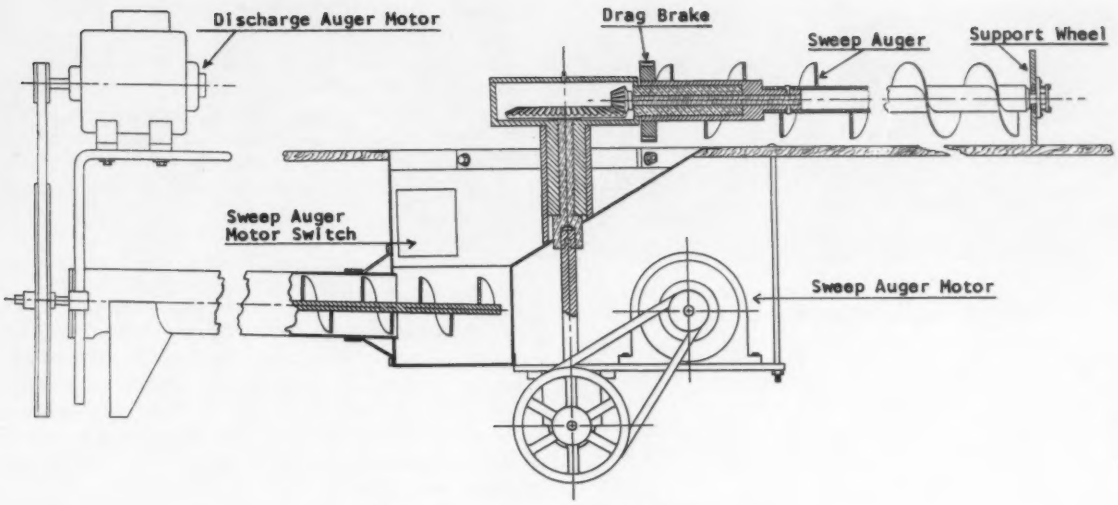


Fig. 3 Sectional view of flat-bottom bin unloader

center of the hopper, which is located in the exact center of the bin and operates a fraction of an inch above the bin floor. This clearance will vary depending upon the trueness of the bin floor. Of course, the closer it is to the floor without touching, the cleaner the bin will be after unloading.

The problem was to power the auger and cause it to press into the stored material with just the proper amount of force. As first conceived, the auger was to be driven through miter gears from a stationary motor. The miter gears were to have a 1:1 ratio, and the final set of two gears were to be free to rotate in the horizontal plane with the auger resting lightly on the floor. The auger was then to be powered into the material by the friction between it and the bin floor. This plan did not work well. When the auger was permitted to be driven forward by the floor, the material was conveyed on the back side of the auger. This left a layer of material several inches deep in the bin. When a guard was placed behind the auger to form a channel for conveying the material, it caused excessive drag and prevented the auger from advancing into the stored material.

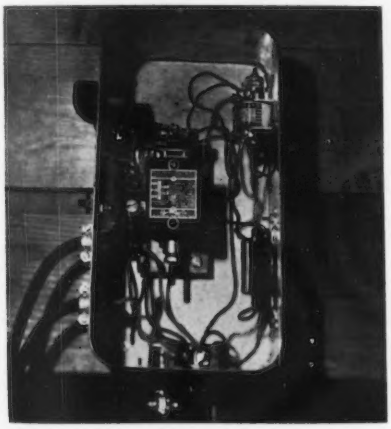


Fig. 4 Current sensitive sweep auger control relay

A reappraisal of the force acting upon the auger suggested a unique drive. If the auger were suspended just above the floor, the torque in the vertical drive shaft driving the second set of miter gears would cause the auger to press into the stored material. The material would then be conveyed on the leading edge of the auger, and the stored material would form the necessary conveying channel. Thus less material would be left behind the auger after the first sweep. Further tests demonstrated that approximately 75 in.-lb of torque would be required to properly load the sweep auger with material. To increase the vertical driveshaft torque, a drag brake was installed on the sweep auger.

The power lost through drag-brake friction was reasonably high (0.21 hp). The ratio of the second set of miter gears was changed so that the auger would run faster than the vertical drive shaft and the proportionate increase in torque would work for the unloader. The result was a decrease in loss of power due to friction (0.07 hp). Various schemes were considered for mechanically advancing the auger, but their complexity suggested that it was best to use a drag brake that would permit the sweep-auger torque to be easily adjusted and to accept the small power loss caused by the drag brake.

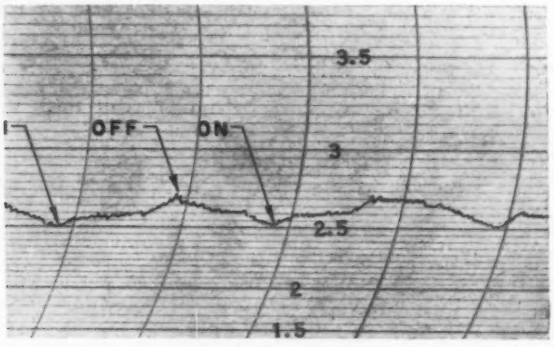


Fig. 5 The discharge auger motor current controlled the sweep auger

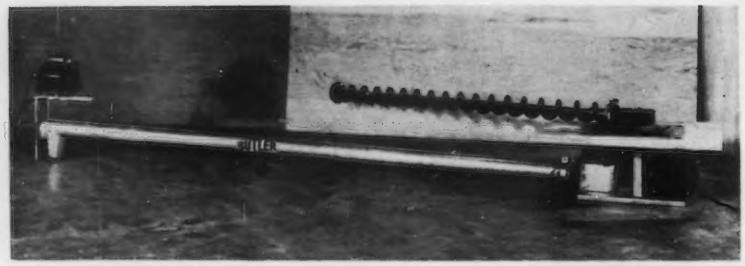


Fig. 6 This automatic flat-bottom bin unloader was installed in a 14-ft diameter steel bin

. . . Automatic Unloader

The constant-torque drive had other advantages. When working into a caked meal, the auger will undercut the material, resulting in the collapse of a large amount on top of the auger (Fig. 2). If the auger were positively driven in the horizontal plane, it would be overloaded for a longer time than with constant-torque drive. With constant-torque drive the auger is able to reverse its rotation in the horizontal plane and is pulled out of the material. This prevents overloading of the sweep-auger motor (Fig. 3).

Some means of controlling the operation of the two augers with respect to each other was necessary. Tests made with both augers operating simultaneously demonstrated this emphatically. To operate the sweep auger when the discharge end of it is covered with the stored material results in a waste of power. It takes considerably more power to operate the auger under these conditions than in normal operation. A mechanical clutch to engage or disengage the sweep auger from the drive motor was considered. To make such an operation automatic would have been cumbersome and expensive. Using two motors, one to drive each auger, was a more desirable solution. Automatic control of an electric motor is simpler than automatic control of a clutch or gearshift.

The motor current of the discharge auger fluctuated with the amount of material being conveyed by the discharge auger. This fluctuation amounted to approximately one ampere. A current-sensitive relay was installed in the discharge-auger-motor circuit which opened the sweep-auger-motor circuit when the discharge-auger-motor was properly loaded (Fig. 4). If the current dropped, indicating a nearly empty auger, the sweep-auger motor was turned on to convey material into the center hopper. This control was automatic and repeated on on-off operation for as long as was necessary to supply material to the center hopper (Fig. 5). Of course, as the bin was emptied, the sweep auger was not able to supply sufficient material to fully load the discharge auger. In this case, the sweep-auger motor ran continuously.

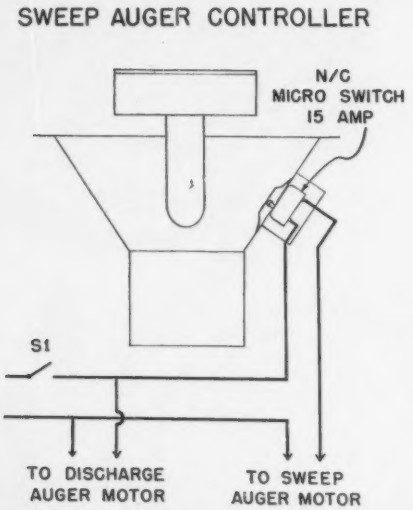


Fig. 7 The pressure-switch sweep-auger controller requires only one electrical device and it is not affected by motor type or the stored material

Another advantage of the automatic control was that, if a bridge occurred in the bin of the stored material, it would be broken immediately. This would probably occur in soybean oil meal and other oil meals. If a bridge were to occur with the auger-type unloader having the automatic sweep-auger control, the sweep auger would operate as soon as the center hopper became empty and would break any bridge that occurred in the bin of stored material. In a round bin the sweep auger would sweep nearly the whole cross section. In a square bin it would sweep about 75 percent of the cross section—that is, sufficient to insure that any bridge would be broken.

The rate of discharge by the unloader is controlled by auger size and the speeds at which they operate, and, of course, the available power. The laboratory model was designed around 6-in. augers; the sweep auger was driven at 150 rpm and the discharge auger at 100 rpm. The unloader withdrew 22,000 lb of shelled corn per hour, or 18,000 lb of soybean oil meal per hour. A ½-hp motor was used to drive each auger. The capacity could be easily

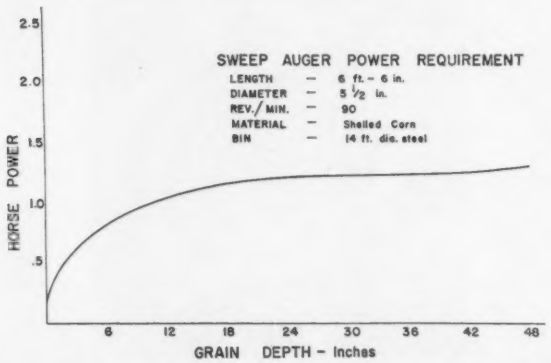


Fig. 8 Sweep-auger power requirement

increased by using larger motors and operating the augers at a higher speed.

An unloader of low capacity will meet our needs. It is contemplated that this unloader will be installed in an active storage bin—one from which frequent withdrawal of material is necessary. An unloader was designed primarily for handling materials automatically at a low rate. It was used to supply feed materials to an automatic grinder, mixer, or conveyor.

A second model was constructed for installation in a 14-ft diameter steel grain bin with 1,000-bu capacity (Fig. 6). This bin was a storage for shelled corn and supplied a 2-hp automatic grinder. A rate of not more than one ton per hour was required from the storage. This model had a 4-in. sweep auger and a 3½-in. discharge auger. To further simplify the unit, the sweep-auger motor was located underneath the bin floor beside the discharge hopper. This eliminated the necessity for concentric shafts and a rigidly fixed position for the discharge auger. It was now possible to raise or lower the discharge auger or shift it from side to side a few inches for easier installation (Fig. 3).

The current-sensitive relay worked well on the laboratory model, but was more complicated than was desirable. On the second model, a pressure-sensitive switch was installed in the discharge hopper to detect the presence of material in the hopper (Fig. 7). This switch in turn directly controlled the sweep-auger motor. When there was no material in the hopper, the switch was in a normally closed position and energized the sweep-auger motor. This conveyed material into the hopper, and the resulting pressure on the switch opened the switch contacts and stopped the sweep-auger motor. This is a control that, because of its simplicity, is more reliable and easier to maintain. Its adjustment is not critical, and it does not need changing to match the characteristics of the discharge-auger motor. Power requirements for this unloader were moderate (Fig. 8).

The 14-ft-diameter bin required an auger with a much longer sweep than had been used in the laboratory tests. This presented two problems: (1) how to obtain sufficient torque in the vertical drive shaft to cause the auger to press satisfactorily into the material, and (2) how to support the greater length to prevent it from rubbing against the bin floor. To provide more torque without a resultant increase in power, a higher ratio miter gear was used in the final drive. A drag brake was also installed, but it was smaller than that installed in the laboratory model. The long auger could not be supported from one end without putting excessive bind on a single bearing. To relieve this bind on the miter gear bearing, a small wheel was mounted on the end of the auger to run on the floor and support the auger at the proper height.

This unit has been very successful and from all indications will meet the need for a simple unloading device for flat-bottom bins used in an automatic materials-handling system.

. . . Fruit and Nut Harvester

(Continued from page 387)

Fig. 8 Field operation of pickup machine on prunes showing high quality of land preparation

tion with no soil disturbance, means that little dirt is picked up. With walnuts, prunes and figs, the amount of fruit missed is negligible. With almonds, however, flat varieties that separate from the hull on falling to the ground are often missed. Any nuts lying in a slight depression will slip under the pickup roll. Tests indicate this problem can be solved by replacing the smooth pickup roll with a small brush. This will increase the amount of dirt picked up, but the indiciations are that the results will be satisfactory(5).

Summary

1 An analysis of pickup principles presently used in commercial machines was made using high-speed movies.

2 Reels rotating with the direction of travel exert a downward component of force on the fruit.

3 Large reels rotating against the direction of travel exert a forward component of force on the fruit which rolls it forward developing a windrow before pickup is accomplished.

4 Knowing the foregoing, research was directed toward developing a principle of pickup to positively pick up the fruit, thereby eliminating windrowing.

5 Using a pickup roll of approximately fruit diameter would result in the desired upward component of force. A second roll placed in front and above this would produce a resultant force through the center of gravity of the fruit thus developing a desirable grasping action.

6 Field tests of machines employing this principle proved the basic principle to be sound, which resulted in the acceptance of two manufacturers who will have machines available the coming season.

7 The new principle has the following advantages: *(a)* Positive pickup, *(b)* small impact force on the fruit, and *(c)* little soil disturbance and consequently a small amount of dirt pickup with no apparent fruit damage.

References

1 Fridley, R. B. and Parks, R. R. Research shows the way, *Western Fruit Grower,* v. 11, June 1957.

2 Fridley, R. B. and Adrian, P. A. Development of prune harvester, *California Agriculture,* v. 12, September 1958.

3 Fridley, R. B. and Adrian, P. A. Studies of prune harvesting, *Prune Program News,* no. 41, July 16, 1958.

4 Adrian, P. A. and Fridley, R. B. Pickup machine tested, *Western Fruit Grower,* v. 12, August 1958.

5 Fridley, R. B. and Adrian, P. A. New pickup machine almond facts, v. 23, Nov.-Dec. 1958.

Soil Compaction by Traffic

William R. Gill

A study of the traffic problem in terms of soil compaction suggests need for improved equipment design and farming practices

SOIL compaction is defined as the act of moving soil particles closer together by external forces such as those which are applied to the soil by agricultural tillage implements, tires, tracks, etc. A certain amount of compaction or firming may be beneficial but when compaction is excessive it may result in deleterious effects to the soils and to the growth of crop plants. One need only consider soil compaction for a short while before he finds that it is a very nebulous phenomenon and in some respects very subtle. It may be one of the more difficult problems to solve by research.

Soil Compaction is Increasing

Soil compaction is increasing because: *(a)* Heavier equipment is being used on farms. Early equipment was designed for use with one or more slow moving draft animals so that most of the equipment was lightweight and the forces applied to the soil by both the animals and the implements were relatively small. The advent of mechanical power, recent mechanization on the farm, and economic considerations have resulted in considerable increases in the weight, speed and power of machinery in crop production. All of these factors are important in the compaction of soils. Under present trends there appears to be no upper limit at which these increases will level off. *(b)* The amount of traffic or the actual number of trips over the soil is also rapidly increasing. One must also include in traffic that compaction which results from animal treading since intensive agriculture also dictates that more animals be grazed on each acre of land for longer periods of time throughout the year. This, plus the trend toward the irrigation of pastures which provides optimum conditions for soil compaction by animals, points to an increase in soil compaction by animals as well as by machines in the future. Increased knowledge in other phases of crop production has shown the advisability of applying large amounts of fertilizer in split applications during the growing season. Pesticides and other sprays are repeated at still different times so that there is a constant stream of traffic over the soil. The number of trips over the soil appears to be steadily increasing, with some justification, and here again it appears that there is no foreseeable upper limit.

Not all dense soil we find results from these traffic forces. The shrinkage forces of drying also compact the soil, while other soils have dense or hard pans which have formed in place in the process of soil formation. In general it may be said that these pans have the same physical significance as traffic pans.

It has been reported that 40 years of cultivation in the prairie soils of Ohio have resulted in an increase in the density of the soils of 20 percent and a decrease in the porosity of 10 percent. Much of this compaction was undoubtedly caused by early disturbances of the soil, decreased returns of organic matter resulting from the removal of native grasses, as well as the compacting effects of traffic over the soil. While the first two of these factors are minimized, the compaction by traffic will increase in the years ahead so that research must be conducted to determine to what extent the consequences will affect the productivity of agricultural soils.

Paper was presented at the Alabama Section, ASAE, Montgomery, Ala., April 1958.

The author—W. R. GILL—is soil scientist, USDA, National Tillage Machinery Laboratory, Auburn, Ala.

Soil Compaction Occurs Under Various Conditions

Soil compaction occurs when forces are applied to the soil while it is in a susceptible condition. As a force is applied to the soil, the soil reacts by compacting until an equilibrium is reached where further compaction does not take place. An increase in the compactive force will result in further compaction or a shear of the soil. Those conditions during which the soil is extremely susceptible to compaction are: *(a)* When the soil is loose and even small forces will result in a decrease in the volume of the soil, *(b)* When the soil is wet and the compressive strength of the soil is low, small forces will again cause the soil to compress and shear, *(c)* When the load is very heavy the pressures applied to the soil will be large so that soil may be compacted even when it is quite resistant to compaction. A more important aspect perhaps may be the fact that the depth of compaction increases with the size of the total load which applies the compacting forces, *(d)* When repeated lighter loads are applied to the soil an increment of increase in compaction is added to the soil with each load application. While perhaps 90 percent of the compaction attainable by repeated loading of the same load is secured by the initial load application, the operation of agricultural equipment is such that repeated loads may not be applied to the same location between the rows of crops. Repeated loading in practice might result in a larger proportion of the area of the field being compacted to the 90 percent point which frequently is sufficiently compact to affect crop plants. Here again the nature of mechanical equipment differs in an adverse manner from that of draft animals. Animal treading covered only small areas in the field while tires and tracks compact continuous strips of soil; therefore, much larger areas of soil are compacted by the use of mechanical equipment because of the nature of the wheel, *(e)* Certain Western soils of low dry cohesive strength are susceptible to compactive damage when dry. These soils are rendered structureless by compaction in the dry condition, an action which results in drastic reductions in crop yields.

Effects of Compaction in Soils

Soil compaction affects the soil in a number of ways. Any or all of these ways may result in an undesirable soil condition. *(a)* Most soil compaction occurs at the expense

of those larger soil pores which are called non-capillary pores. These pores are the means by which the soil rapidly transmits water and gases throughout the soil. The smaller pores which hold the majority of water which is held after rains are only slightly affected by compaction. *(b)* Compaction of the soil into a smaller volume may be measured in terms of an increase in bulk density. Along with this bulk density increase is an increase in the mechanical strength of the soil mass. Thus the soil becomes harder as a physical mass. This hardness is the soil strength which must be overcome by tillage implements or by the growing root as it extends into the soil. *(c)* Compaction of soil results in the movement of soil particles by the applied forces. Directly under the wheel the direction will be predominately forward and downward, while along the sides of the wheel the movement will be forward and outward. Dependent upon the magnitude of the compacting force and the resistance to deformation of the soil, movement will vary from a maximum under the tire to a minimum at some distance from the tire. *(d)* Extreme compaction results in a deformation of the soil which is not easy to remove. Under extreme conditions these ruts may hamper the operation of mechanical equipment. Ruts also have a low permeability and favor the channeling of water off the field or in low areas form pockets which retain water for long periods of time.

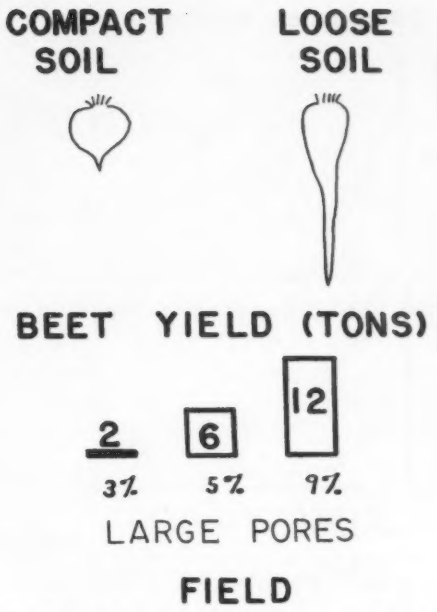


Fig. 2 The influence of soil compaction on sugar beets

Soil Compaction Affects Plant Growth

Compaction in the extreme also affects the growth of crop plants and trees. The degree of plant injury hinges on the importance of other soil and climatic factors so that it is frequently difficult to evaluate. As an example, a tree with roots impeded by a dense soil may never be affected by this condition until a severe wind storm uproots it. Those soil conditions resulting from the compaction of soil affect the growth and activity of plant roots in several manners: *(a)* A reduction of the percentage of macropores of the soil results in a decrease in the capacity of the soil to infiltrate water into and transmit it through the soil profile. Complete recharge of the soil profile by natural rainfall or irrigation can only take place when the water can be taken into the soil. Reduction of the infiltration and transmission of the water in the soil results in an increase in the amount of surface runoff of water. Under certain conditions this may result in the failure of the subsoil to be recharged before the growing season starts. Where irrigation is practiced this can lead to reduced irrigation efficiency. Along with the runoff of surface water the erosion of the soil becomes an important consideration. *(b)* The decrease in macroporosity caused by compaction decreased the volume of air space available in the soil. Since all plant roots require oxygen for respiration and growth, the decrease in aeration may have almost immediate effects on plants. It might be well to also consider briefly the indirect effects of aeration as they are related to the development of root growth pressures and the extension of roots into soil. If a soil has certain chemical elements such as iron and manganese present in certain forms, these elements may be changed into a reduced state at lower oxygen levels. Reduced forms of iron and manganese are frequently toxic so that their presence would also affect the root and complicate the direct effects. Chemical and nutritional reasons for impedance are not basically mechanical in nature but are frequently difficult to separate from mechanical impedance. *(c)* While we rarely consider the mechanical strength of roots, this strength becomes important when a differential movement of soil takes place under a wheel. Movement of the soil may result in the tearing and crushing of plant roots. *(d)* The mechanical strength of the soil must be overcome by the growing roots. Increasing the soil

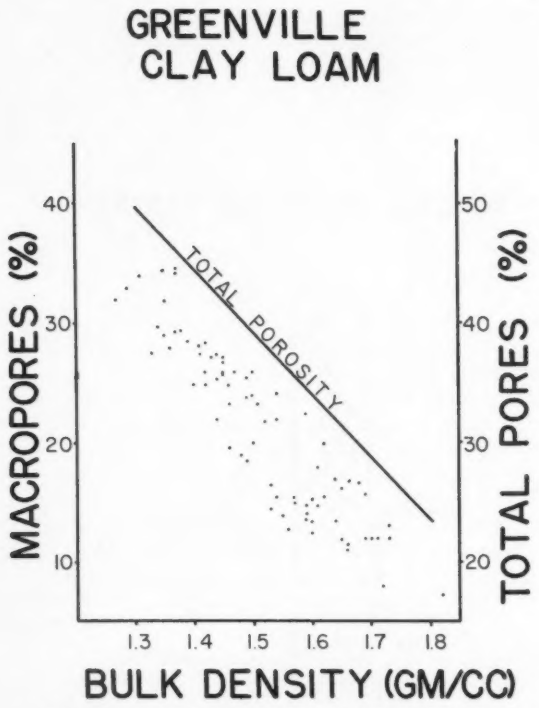


Fig. 1 The percentages of macro and total pores present at different bulk densities in a Greenville clay loam soil

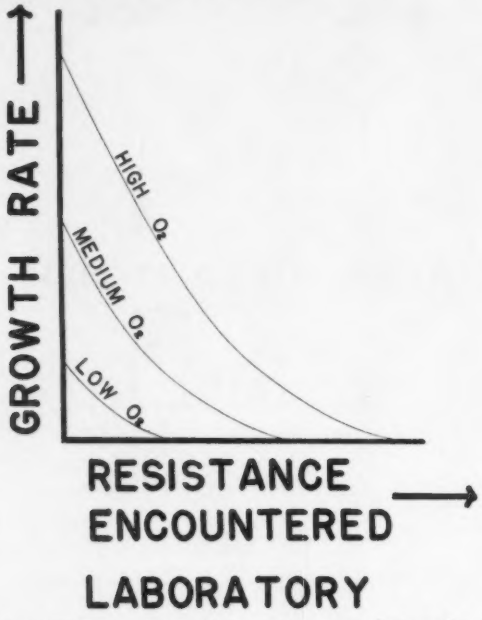


Fig. 3 Seedling root growth rates as functions of external resistances encountered and various levels of aeration

strength by compaction makes root extension more difficult. Restriction of roots to shallow depths reduces the soil reservoir of nutrients and moisture which would normally be available to the plants. Under extreme conditions, this condition results in reduced crop yields. Along with an increase in the mechanical strength due to compaction is a reduction in the actual pore size. Roots are not able to grow into openings smaller than the root diameter; hence the size of the pores is important, especially when the soil is cemented. When pores are large enough so that roots can penetrate without the necessity of enlarging a path through the media, root growth will be rapid.

Facts Through Research

Research has been able to show the importance of some of the factors presented above. A correlation between laboratory measurements of the percentage of macropores and the bulk density of a clay loam soil are shown in Fig. 1.

The solid line on the graph which indicates the total porosity of the soil is essentially parallel to the slope of the macropore versus density plot. It can be concluded that the loss in the percentage of the pore space due to compaction has taken place almost exclusively at the expense of the macropores in this soil.

Results of some field experiments conducted in Ohio with sugar beets are shown in Fig. 2. The yield of beets was greatly affected by the percentage of macropores in the soil, so that one can see the importance of these pores is established in terms of plant growth. A decrease in the percentage of macropores also affected the shape of the beet roots. Those roots growing in soils of low porosity were generally shorter and had a lower percentage of sugar than those grown in soils of higher porosity. Fortunately, the percentage of macropores which may be decreased by traffic may also be increased by tillage and other practices so that remedy of the compact conditions is possible.

Some results of laboratory experiments on the mechanical impedance of roots which were conducted in New York are shown in Fig. 3. Roots of corn seedlings were grown against an external media through a range of increasing mechanical resistances. The mechanical resistance had to be overcome by the growth of the roots. Rates of root growth were found to decrease as the root encountered higher external mechanical resistances. Ultimately a point was reached where the root was completely impeded by mechanical forces. It is also apparent from the data that a decrease in the oxygen percentage in the root zone resulted in a decrease in the rate of growth of the roots. A third important point which is shown by the data is that the capability of the plant root to develop its growing pressure was also reduced by a decrease in the oxygen percentage. One can understand why a mechanical probe, such as a soil penetrometer, can never be used satisfactorily to determine threshold soil resistances above which roots will not penetrate, since it does not consider soil aeration.

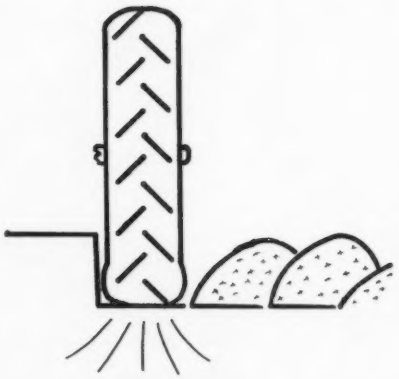
Equipment Design to Minimize Soil Compaction

Considering that soil compaction by traffic is presently increasing, there are certain things which can be done to assist in the elimination or minimization of soil compaction. It is entirely feasible to design machinery with a viewpoint of minimizing compaction.

The cross section of a field being plowed, where the tractor wheel is operating in the bottom of the plow furrow, is shown in Fig. 4. Structure destroying forces are being applied to the bottom of the plow furrow which is a zone where the soil preparation is already completed. The next furrow slice will cover the soil damage which is caused at the time of plowing. If this wheel were to ride on the unplowed surface along the edge of the furrow, those forces would be applied to soil which would in general be drier and therefore less susceptible to damage. A more important point, however, is that any damage inflicted by the wheel

(Continued on page 400)

WHEEL IN PLOW FURROW?



DESIGN

Fig. 4 The compaction of soil by a tractor wheel in the furrow at the time of plowing

Theoretical Aspects of Unsaturated Flow in Drainage and Subirrigation

Herman Bouwer
Assoc. Member ASAE

Numerical procedures proposed for obtaining solutions under realistic conditions of flow

CONDITIONS of steady two-dimensional unsaturated flow of moisture in soil that may be of importance to the agricultural engineer are encountered in problems of subsurface drainage, subirrigation, canal seepage, groundwater recharge, infiltration from irrigation furrows or infiltrometers, seepage through dams and levees, and others. In the past, not much attention has been paid to the unsaturated-flow phases, perhaps mainly because of the complexity of their quantitative evaluation and the fact that the unsaturated flow can be legitimately ignored under certain conditions(4)*.

Steady unsaturated flow is essentially a problem of flow in a medium with gradually changing conductivity and with interdependent tension and conductivity. In view of these conditions, numerical procedures seem to offer the best possibility for obtaining solutions under realistic conditions of flow. Numerical solutions by conventional relaxation procedures, however, tend to be extremely tedious because of the small mesh size required in regions with rapid changes in conductivity as well as in regions with marked convergence or divergence of streamlines. Since tension and conductivity are interdependent and both unknown for most of the unsaturated zone, a number of relaxations with conductivity to tension adjustment after each relaxation is required before a relaxed system is obtained with a tension-conductivity distribution that satisfies the tension-conductivity relationship for the medium in question. In a recent article(3), however, it is shown that relatively rapid solutions can be obtained by the use of "equivalent conductivities" and an electrical resistance network. The use of equivalent conductivities eliminates the need for fine or subdivided grids for reasons of rapid conductivity changes with respect to distance. The electrical resistance network serves as an analogue for automatic relaxation of the system. The method discussed in(3) is applicable to partially or entirely unsaturated systems in media that may be of a uniform or a non-uniform physical composition. The systems are treated in their entirety with simultaneous solutions of coexisting saturated and unsaturated phases. The locations of these phases do not have to be known *ab initio*, but they can be evaluated after the analyses by constructing contours of zero tension as the lines separating the saturated and the unsaturated zones. The solutions of the flow systems in this paper were obtained with the method presented in(3).

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The author—HERMAN BOUWER—is associate agricultural engineer, Agricultural Experiment Station, Alabama Polytechnic Institute.

Acknowledgment: The author acknowledges the valuable assistance of J. M. Yeager, senior agricultural engineering student, in performing the flow analyses.

*Numbers in parentheses refer to appended references.

Conductivity-tension relationships

To solve problems involving unsaturated flow, it is necessary to know the conductivity-tension relationship applying to the material in question from a standpoint of physical composition and hysteresis. The latter is determined by preceding moisture conditions. These relationships are usually S-shaped with near saturated-conductivity at the lower tensions and a rather sudden conductivity reduction with subsequent flattening out as the tension is increased. In view of the theoretical character of this paper and to facilitate the calculation of equivalent conductivities (3), hypothetical conductivity-tension relationships with straight-line connections between pertinent points were used for the flow systems in this study. The tension at which the conductivity undergoes a rather sudden reduction is called the critical tension(4). In case this reduction extends over a certain range of tensions, the critical tension can be taken as the center of that range.

The critical tension serves only to facilitate distinct designation of the capillary fringe, which can now be defined as the zone between the water table (zero-tension contour) and the critical-tension contour. Since the flow rates in the capillary fringe are usually small compared to the conductivity in the capillary fringe, the tensions in the fringe are nearly the same as under static conditions so that the thickness of the capillary fringe is numerically almost equal to the critical tension. The effect of the capillary fringe on the flow system is due to an increase in the dimensions of the effective flow region. The other pertinent factor in the flow system, the over-all head, is determined by the position of the water table or by some maximum permissible tension at a given point (see under "subirrigation").

Nomenclature

K = hydraulic conductivity in centimeters per day
ψ = soil moisture tension in centimeters of water
ψ_e = critical tension in centimeters of water
L = horizontal distance in cm between center of drains or ditches.

The term "potential" in this paper is expressed in centimeters and refers to the sum of the pressure (positive) or the tension (negative) and the elevation above a certain horizontal datum.

Fig. 1 Drainage flow system in shallow uniform soil with a critical tension of —50 cm. The tension contours are indicated by broken lines. The potentials are expressed in centimeters and refer to the horizontal line between the center of the drains. The network used in the analogue is indicated by the dots

Tile Drainage

The effect of the thickness of the capillary fringe and the conductivity above the capillary fringe on the drainage coefficient is discussed in a previous paper(4) for a shallow homogeneous tile-drained soil. The effect of the capillary fringe appeared to be appreciable and it is shown that Hooghoudt's method(7) could be used to include fringe effects in the calculation of drainage coefficients. The effect of the conductivity above the capillary fringe on drainage coefficient appeared to be small(4). The term "drainage coefficient" as used here applies to the actual drainage rate of the system under certain equilibrium conditions.

Under field conditions, soils tend to be non-uniform with the topsoil frequently having a higher conductivity than the subsoil (8, 11). Under high water table conditions, the capillary fringe may extend into the topsoil so that the higher conductivity of the upper layers becomes of benefit to the drainage flow. This effect is illustrated in Figs. 1 and 2, which have the following geometry and boundary conditions:

Depth of drains 100 cm below field surface and L=960 cm

Depth of impermeable layer 120 cm below field surface

Tile diameter of 5 cm with atmospheric pressure around the periphery

Water table 20 cm below field surface midway between drains

A uniform steady rate of water infiltration across the field surface.

The hypothetical conductivity-tension relationship for the flow system of Fig. 1 was selected as K linear with ψ between

ψ	0	—40	—50	—51	—140
K	25	25	24	5	2.7

The same relationship was used for the system of Fig. 2 except for a higher conductivity in the top 20 cm of the soil. For this zone K was selected linear with ψ between

ψ	0	—40	—50	—51	—140
K	125	125	120	12.5	1.0

so that the conductivity of the topsoil was five times the conductivity of the subsoil. The critical tension being 50 cm, the thickness of the capillary fringe was approximately 50 cm for both systems. Since the depth of the water-table midway between the drains was 20 cm, the capillary fringe extended to the field surface for the majority of the distance between drains. The following drainage coefficients

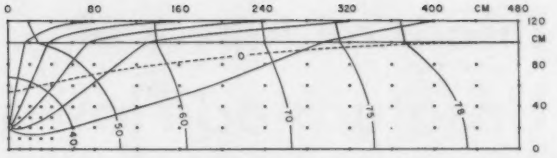


Fig. 2 Drainage-flow system in shallow soil with a critical tension of —50 cm. The conductivity of the top 20 cm of the soil is five times as high as the conductivity of the subsoil. The top of the capillary fringe (tension contour of —50 cm) occurs just in the upper-left corner of the flow system

(centimeters per day) were determined by electrical current measurements:

Uniform soil neglecting the capillary fringe	1.09
Uniform soil including the capillary fringe (Fig. 1)	1.36
Soil with capillary fringe extending into topsoil with higher conductivity than the subsoil (Fig. 2)	1.73

The increase in drainage coefficient by a capillary fringe extending into a more permeable topsoil is evidenced by the pattern of streamlines in Fig. 2 compared to the pattern in Fig. 1. The "subsurface flow" in permeable topsoils has been used by Bouwer(1) as an argument in favor of installing tile drains in sloping fields almost parallel to the contours. The flow in the plow zone is mentioned by Wesseling(10) as an explanation for his observation that measured drainage rates exceeded calculated drainage rates at high water tables.

Tile drainage of fields where the conductivity of the subsoil is very low compared to the topsoil may be of questionable merit, since most of the flow will take place as subsurface flow. A shallow drainage facility for removing the water from the topsoil may be more appropriate under those conditions.

The water table in Fig. 2 appears to be higher over the drains than in Fig. 1. This suggests that flatter water tables can be expected with increasing contribution to the drainage flow from the zone above the water table. The same effect was noticed in a study of the influence of the capillary fringe(4). In all cases, the pressure on the tile periphery was taken as atmospheric.

Another type of drainage problem that may be encountered is in connection with artesian water. Normally the most effective way of lowering the water table under those conditions is by means of pumping from a well extending into the aquifer. Sometimes, however, this method

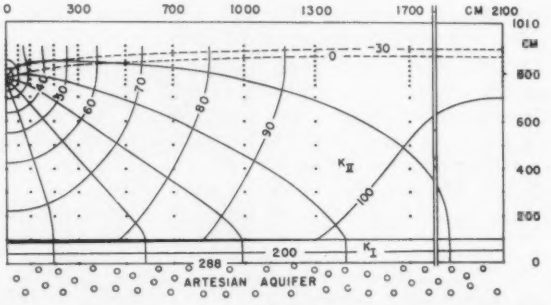


Fig. 3 Drainage-flow system with an artesian aquifer, $K_I=1$ and $K_{II}=100$. The potentials are in centimeters and refer to the center of the drain. The tension contours (broken lines) indicate the water table and the top of the capillary fringe, respectively

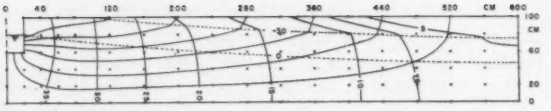


Fig. 4 Subirrigation flow system with a shallow impermeable layer. The tension contours are indicated by broken lines. The potentials refer to a horizontal datum 60 cm below the surface of the field

conflicts with local laws or interests of other users of the artesian water. Tile drains may be effective where the conductivity of the soil is not too low and the aquifer is overlain by a layer of relatively low conductivity. An example of a flow system under such conditions is shown in Fig. 3. The thickness of the slowly permeable layer above the aquifer was selected as 100 cm and the conductivity K_1 as 1 cm per day. The K—ψ relationship for the rest of the soil was taken as K linear with ψ between

ψ	0	−20	−30	−31	−120
K	100	100	96	10	0.8

The solution showed that an 8-in. tile at a depth of 240 cm (8 ft) and a spacing of 4200 cm (138 ft) lowers the water table to 140 cm (4.6 ft) below field surface midway between the drains in the presence of an artesian aquifer at a depth of 1010 cm (33 ft) with a pressure head of 48 cm (1.6 ft) above field surface. The drainage coefficient determined by current measurement was 1.97 cm per day, which corresponds to a drain discharge of 0.103 cfs per 1000 ft of tile. In view of the low conductivity above the capillary fringe, the drainage flow in the top 100 cm of the soil was considered negligible.

Subirrigation

The method for unifying solutions of partially unsaturated flow systems (3) offers a rather important feature in the analysis of flow problems related to subirrigation, since it is possible to specify an unrestricted availability of moisture to the crop directly in terms of some maximum permissible tension at a given point instead of some maximum depth to the water table. To avoid the problem of gradually reducing upward flow rates as the moisture is being absorbed by the roots, the upper boundary of the flow system is taken as the bottom of the zone with most of the root activity. It is assumed that all the water necessary to meet the consumptive use must be supplied to this level at a rate that is uniform with distance. It will be clear that the lowest moisture level will occur at this upper boundary of the flow system midway between the subirrigation ditches, so that the maximum permissible tension must be maintained at that point.

The maximum permissible tension at the point of lowest moisture level at the bottom of the root zone must be selected on the basis of moisture availability to plant roots. Since the conductivity at higher tensions is usually very small, increasing the maximum permissible tension much beyond the critical tension tends to have little effect on the upward flow rate or on the spacing between the subirrigation lines (3).

The uniform rate of moisture withdrawal at the bottom of the zone with most of the root activity must be selected on the basis of crop consumptive-use rates, which are unsteady with peak rates occurring in the daytime and low rates during the night. It is speculated in this study that the

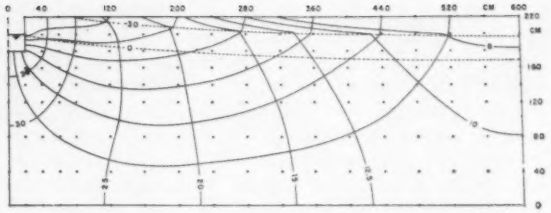


Fig. 5 Subirrigation flow system with a deep impermeable layer. Other conditions are the same as in Fig. 4

design rate of upward flow should be in excess of the average daily rate, but not quite as high as the actual peak rates.

The spacing between subirrigation lines required to meet the design consumptive-use rate and the desired maximum permissible tension at the point of lowest moisture level, is found by trial and error. Upward flow rates are adjusted to a uniform value and are determined for several spacings while maintaining the desired maximum permissible tension. The spacing giving the design consumptive-use rate is then determined by interpolation.

The procedure for numerical solution of partially unsaturated flow systems (3) has been applied to analyze and compare subirrigation flow systems at different depths of the impermeable layer (Figs. 4 and 5) and for different degrees of internal drainage in the absence of an impermeable layer (Figs. 6 to 11 inclusive). The K—ψ relationship for figures 4 to 9 inclusive is hypothetical and was selected as K linear with ψ between

ψ	0	−20	−30	−31	−120
K	50	50	48	5	0.4

This relationship produces a capillary fringe of approximately 30 cm. Figs. 10 and 11 apply to an actual soil (Indio loam) for which the conductivity-tension relationship(3) was determined by the U.S. Salinity Laboratory, Riverside, Calif. All flow systems presented, except Fig. 4, have a design consumptive-use rate of approximately 1.5 cm per day. This figure is based on the actual amount of land surface between the ditches.

Absence of deep seepage losses occurs in the presence of a horizontal or saucer-shaped impermeable layer. A subirrigation system with a shallow horizontal impermeable layer is shown in Fig. 4. The maximum permissible tension at the point of lowest moisture level was 60 cm. The upward flow rate was measured as 0.88 cm per day. In view of the shallow impermeable layer, the horizontal flow assumption [Dupuit-Forchheimer; see for example Kirkham(9)] can be considered applicable. The flow rate thus calculated was 0.90 cm per day, including the effect of the capillary fringe. Without capillary fringe, a less satisfactory agreement was obtained, *i.e.*, 0.61 cm per day. To obtain an upward flow rate in line with the other subirrigation systems in this paper (1.5 cm per day), the ditch spacing must be reduced from 1,200 to 920 cm. Because of the near-saturated conductivity in the capillary fringe, the stream lines pass through the fringe without much change in general direction (Fig. 4). Upon leaving the capillary fringe, however, the direction of the stream lines becomes more vertical.

A flow system similar to Fig. 4, but with a deep impermeable layer, is shown in Fig. 5. The horizontal-flow assumption gives flow rates that are too high under these

conditions, *i.e.*, a calculated flow rate of 1.8 cm per day including the fringe effect compared to a flow rate of 1.4 cm per day measured with the resistance network. A more accurate method for predicting flow rates in the presence of relatively deep impermeable layers is the one by Hooghoudt (7), which gives a flow rate of 1.5 cm per day for the system of Fig. 5.

In the forgeoing comparison between subirrigation flow rates measured with the resistance network and those calculated by approximate methods, the differences in water-table heights used in the latter were graphically determined from the flow analyses with the resistance network. If a resistance network is not available, it is still possible to use the concept of maximum permissible tension at the point of lowest moisture level in the design of subirrigation systems by approximate methods such as Hooghoudt's(7). It is then necessary to know the conductivity-tension relationship for the soil in question so that equivalent conductivities for vertical flow can be calculated(3). With this information, the depth of the water table below the point of lowest moisture level can be determined from the maximum permissible tension at that point and the design-upward flow rate. The desired ditch spacing can then be computed.

The increase in the depth of the impermeable layer from Fig. 4 to Fig. 5 resulted in an increase in the upward flow rate from 0.88 to 1.4 cm per day. This effect continues until the depth of the impermeable layer is approximately equal to L/4 (see references to Hooghoudt and Van Deemter in reference 2). Further increases in depth have very little effect on the flow rate, so that in this respect the depth of the impermeable layer can be considered infinite when it has a value of approximately L/4 or more.

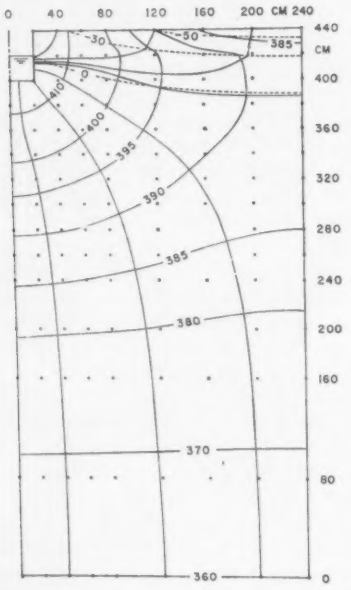


Fig. 6 Subirrigation flow system in a soil with limited internal drainage. Tension contours are indicated by broken lines. The network used in the analogue is indicated by dots. The potentials refer to a horizontal datum 440 cm below the upper boundary of the flow system

A subirrigation system with limited internal drainage is shown in Fig. 6. The limited seepage in this problem was obtained by assuming a certain horizontal pressure contour in the groundwater at a certain depth (a pressure of 360 cm at a depth of 440 cm in Fig. 6). Again a uniform rate of moisture withdrawal at the upper boundary of the flow system and a tension of 60 cm at the point of lowest moisture level were maintained. The flow rates were measured to be 1.7 cm per day in upward direction and 4.7 cm per day in downward direction. Since the total daily upward flow cannot exceed the daily consumptive use of the crop, the irrigation efficiency would be 11 percent if the crop consumptive use is assumed to be 0.6 cm per day and the seepage flow is assumed to remain constant at 4.7 cm per day.

The water table in Fig. 6 (0-tension contour) appears to extend directly from the water level in the ditches to the lowest point of the water table midway between the ditches. The streamline reaching the line of symmetry midway between the ditches at a right angle separates upward flow and downward flow.

The occurrence of deep seepage reduces the ditch spacing considerably if satisfactory flow rates must be maintained (compare Figs. 5 and 6). To illustrate the effect of seepage, the system of Fig. 6 was also analyzed with groundwater pressures of 350 cm and 340 cm at 440 cm depth. The results were as follows:

Pressure at 440 cm depth	Downward flow, cm per day	Upward flow, cm per day	Depth, cm, of water table below top of flow system midway between ditches
360	4.7	1.7	51
350	5.8	1.1	54
340	6.7	0.5	57

Extrapolation shows that the rapidly decreasing upward flow rate becomes zero, if the water table midway between the ditches reaches a depth of 60 cm below the top of the flow system. Since the tension at the point with lowest moisture level is maintained at 60 cm, static conditions are then reached and the ditch spacing must be reduced before upward flow midway between the ditches can be resumed.

Virtually unrestricted internal drainage is obtained when the groundwater pressures at relatively great depths are reduced to low values. Figs. 7 and 8 show a flow system in the presence of a water table at 440-cm depth where it is assumed that the water is discharged below the water table at the same rate as it is transmitted downward by the soil above the water table. The maximum permissible tension at the point of lowest moisture level was selected as 70 cm. The upward flow rate appeared to be 1.5 cm per day and the downward flow rate 47.5 cm per day, *i.e.*, almost equal to the saturated conductivity. The efficiency is extremely low and very small ditch spacings must be employed to maintain unrestricted moisture availability to the crop. The tension contours (Fig. 8) indicate the presence of an oval-shaped water table below the ditches. The rest of the flow system above the deep water table is at very low tension except for a zone with higher tensions near the upper boundary of the medium.

The tension contours in Fig. 9 apply to the same flow conditions as in Figs. 7 and 8, except that the groundwater pressure at a depth of 440 cm is increased from 0 to 16 cm water. The unsaturated zone at some distance below the

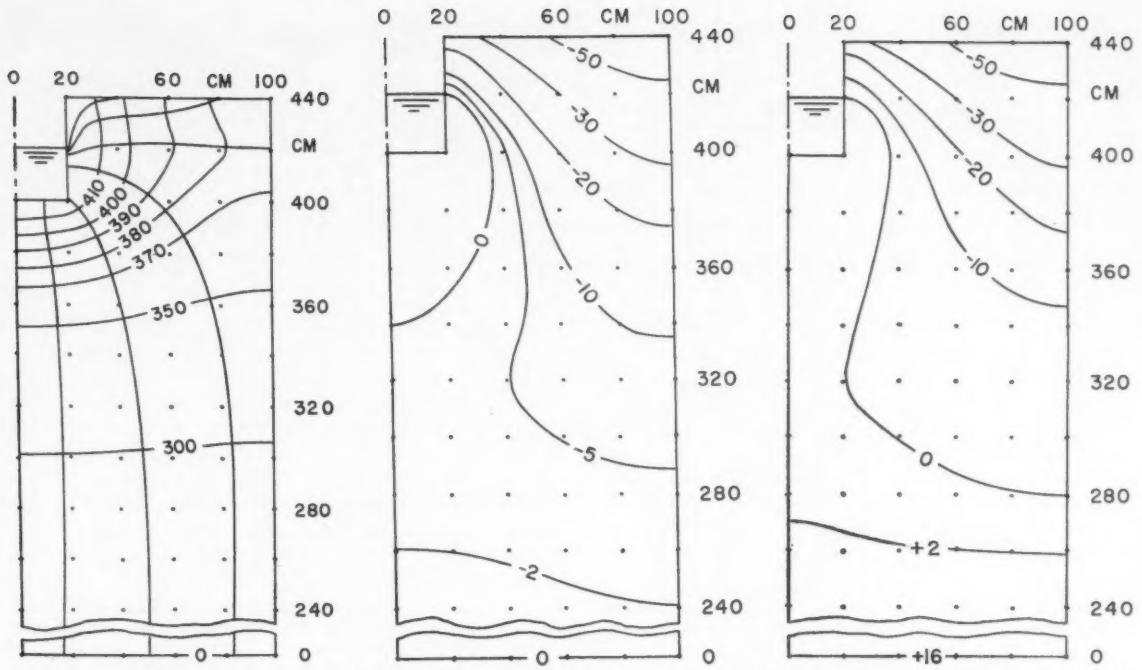


Fig. 7 *(Left)* Subirrigation flow system in a soil with virtually unrestricted internal drainage. The potentials refer to the level of the permanent water table at 440 cm below the top of the flow system. The network in the vertical direction is identical to the network in Fig. 6 • Fig. 8 *(Center)* Tension contours for the flow system of Fig. 7 • Fig. 9 *(Right)* Tension contours for a subirrigation flow system with a ground-water pressure of 16 cm at a depth of 440 cm. Other conditions are as in Fig. 7

ditches has disappeared and a definite water table extending directly from the water level in the ditches to the lowest water-table point midway between the ditches has been formed. The water table midway between the ditches is too low, however, to produce upward flow to the top of the flow system. The flow across the upper boundary of the flow system is supported mainly by a lateral unsaturated flow in the upper zone of the flow system as in Fig. 7. The flow rates were approximately the same as for the system of Fig. 7, *i.e.*, 1.6 cm per day upward flow and 45.0 cm per day downward flow.

In case of small spacings between ditches, underground pipe lines may be more satisfactory. A subirrigation system with underground pipe lines is shown in Figs. 10 and 11 for an actual soil (Indio Loam). A pressure of 60 cm of water was maintained along the periphery of the underground tubing in this system, which in the presence of a permanent water table at great depth resulted in the formation of an oval-shaped zone of saturation around the pipe. Other boundary conditions of this flow system are similar to the subirrigation system presented in(3). The flow rates determined by current measurements were 1.5 cm per day in an upward direction and 1.75 cm per day in a downward direction. The lower seepage losses can be explained by the lower saturated and near-saturated conductivity of the Indio loam and the greater degree of divergence of the downward streamlines.

The low efficiency of subirrigation in the absence of restricting layers may be of advantage in case the major objective of the system is disposal of water, for instance in connection with disposal of partially treated sewage or other wastes. Sewage disposal by subirrigation with underground tubing is practiced to some extent in Germany and may receive more attention in this country in view of increased stream pollution and progress in the development of low-cost mechanically installed underground tubing for drainage or irrigation purposes.

It is of interest to consider the subirrigation analyses in this study in the light of a paper presented by Fox *et al*(5) and subsequent discussions (2, 6). In that article(5), the water table was taken as being at some distance below the bottom of the ditches with an unsaturated zone of seepage between ditch bottom and water table. Water seeped from the ditches to the water table, after which it was transmitted below the water table to the crops. The horizontal-flow assumption was then employed for further theoretical treatment. In the analyses of this study, however, unsaturated zones below the ditch bottoms do not exist. Only in the event of almost unrestricted seepage in the presence of a permanent deep water table were the lower soil regions unsaturated. Under those conditions, however, the horizontal-flow assumption cannot be applied.

Summary

A recently developed procedure for unifying numerical analyses of water flow in entirely or partially unsaturated media of uniform or non-uniform composition(3) has been applied to some selected drainage and subirrigation problems to exemplify the type of problems that can be solved with the procedure and to present an evaluation of the importance of unsaturated flow in these problems. Hypothetical conductivity-tension relationships were employed in

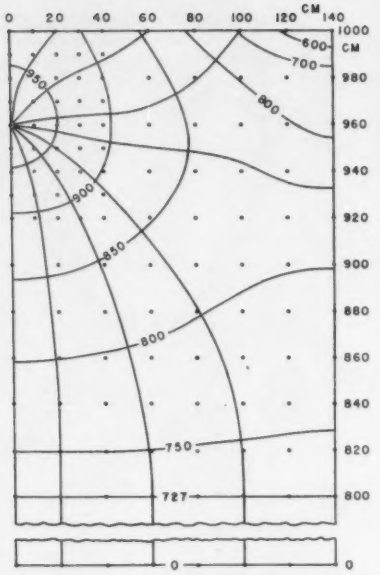


Fig. 10 Subirrigation flow system with underground tubing in Indio loam. The potentials refer to the level of the permanent water table at 800 cm below the top of the flow system

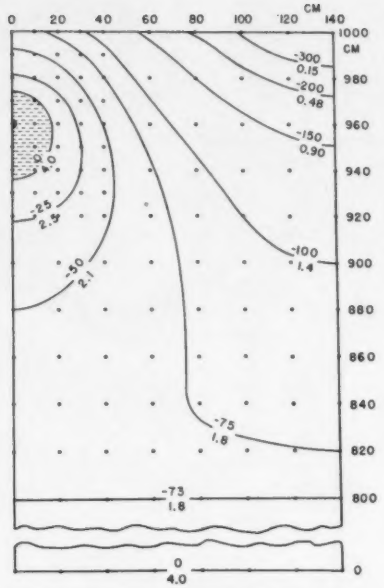


Fig. 11 Contours of tension (upper figures) and conductivity (lower figures) for the flow system of Fig. 10

most of this study. The same principles, however, can be applied in the solution of flow problems for actual soils if the particular conductivity-tension relationships are known.

A comparison of the results of the flow analyses with those obtained by approximate methods for solution indicated that reasonably accurate results can be obtained with Hooghoudt's method(7). The applicability of approximate methods, however, is limited. The importance of unsaturated flow in the surface soil in case of subsurface drainage is demonstrated with an example whereby the capillary fringe extended into a permeable topsoil. Analyses of subirrigation flow under different conditions of internal drainage showed that the water table generally extends directly from the water level in the ditches down to the lowest water-table point midway between the ditches. Unsaturated conditions in the lower soil regions occurred only in a case of unrestricted water disposal below a permanent deep water table.

With the method for unifying solution of partially unsaturated flow systems, the subirrigation requirement of unrestricted moisture availability to plant roots could be directly expressed in terms of a maximum permissible tension at the point of lowest moisture level rather than in terms of a maximum depth of the water table.

References

1 Bouwer, Herman. Tile drainage of sloping fields. AGRICULTURAL ENGINEERING 36, 400-403, 1955.

2 Bouwer, Herman. Reader's Forum, AGRICULTURAL ENGINEERING 38, 186 and 202, 1957.

3 Bouwer, Herman and Little, W. C. A unifying numerical solution for steady two-dimensional flow problems in porous media with an electrical resistance network. Soil Science Society of America Proc. 23, 91-96, 1959.

4 Bouwer, Herman. Theoretical aspects of unsaturated flow in tile drainage of shallow homogeneous soil. Soil Sci. Soc. Amer. Proc. Scheduled for July-August issue 1959.

5 Fox, Roy L., Phelan, John T. and Criddle, Wayne D. Design of subirrigation systems. AGRICULTURAL ENGINEERING 37, 103-108, 1956.

6 Fox, Roy L., Phelan, John T. and Criddle, Wayne D. Reader's Forum, AGRICULTURAL ENGINEERING 38, 868, 876, and 878, 1957.

7 Hooghoudt, S. B. Bydragen tot de kennis van enige natuurkundige grootheden van de grond, No. 7. The Hague, Holland, 1940.

8 Kirkham, Don, and de Zeeuw, J. W. Field measurements for tests of soil drainage theory. Soil Sci. Soc. Amer. Proc. 16, 286-293, 1952.

9. Kirkham, Don. Seepage of steady rainfall through soil into drains. Trans. Am. Geoph. Union 39, 892-909, 1958.

10 Wesseling, J. The relation between rainfall, drain discharge, and depth of water table in tile-drained land. Netherlands Journal of Agric. Sci. 6, 47-61, 1958.

11 Zwerman, P. J. and Bouwer, Herman. Unpublished field permeability data with the auger-hole method. Cornell University, 1954.

. . . Compaction by Traffic

(Continued from page 394)

would be removed to a great extent by the tillage in progress. The farmer is not able to remove this wheel from the plow furrow. If necessary, it would be possible for implement manufacturers to design equipment so that this wheel could be taken from the furrow.

Design may also be such that it minimizes the forces applied to the soil regardless of where they are applied. It has been shown that compaction by two such contrasting tires as the normal tire, which applies a high pressure over a small area, and the larger low pressure tire or track, which applies a low pressure over larger areas, may compact soil at deeper depths to essentially the same degree. Thus if one considers the maximum force which the soil could withstand and yet produce an economic yield, one might be able to design equipment from the standpoint of what the soil could bear. This approach is different from that in which one starts with a heavy machine which must be supported and attempts to reduce the soil compaction by increasing wheel or track size to achieve low unit pressures on the soil.

(Continued on Page 402)

Precise Temperature Control with Thermocouples

J. L. Thames and S. J. Ursic

Regulation of temperature in experimental work is obtained through use of an economical and easily-assembled arrangement of laboratory equipment

A CONVENIENT and economical way of applying a portable potentiometer and a photoelectric circuit has been devised for precise control of temperatures in experimental work. The system makes use of a mirror galvanometer, which is standard equipment on many precision potentiometers.

The arrangement differs from previous systems (1, 2, 3)* in having a simplified circuit, using a small photocell, and requiring no optical system or alterations to the galvanometer. It is easily assembled and can hold temperatures to within ± 0.3 F. over extended periods. The cost, excluding the potentiometer, is less than 35 dollars.

Paper prepared expressly for AGRICULTURAL ENGINEERING.

The authors—J. L. THAMES and S. J. URSIC—are members of the Tallahatchie Research Center, which is maintained at Oxford, Miss., by the Southern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, in cooperation with the University of Mississippi.

*Numbers in parentheses refer to the appended references.

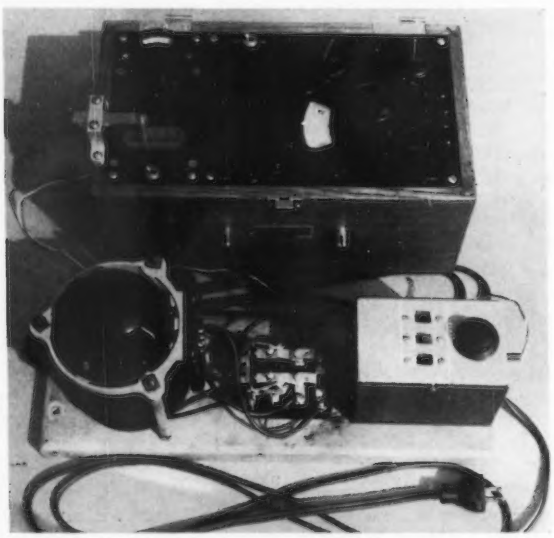


Fig. 1 Regulator components. The photocell mount is shown above the scale of the galvanometer

Construction

The heart of the regulator is a cadmium photoconductive cell ¼-in. in diameter and about ¾-in. long, whose electrical resistance varies with the incident illumination. The photocell controls the bias on the grid of a thyraton tube which in turn operates a small relay. The complete photorelay can be purchased as a compact unit in kit form† and assembled in a few hours from pictorial diagrams. The only alteration is to attach longer leads to the photocell.

The output of the photorelay (6.3 volts) operates a secondary double-pole, double-throw, power relay capable of handling loads up to 20 amps. A 115-volt variable transformer with an output of 0 to 140 volts may be added to allow a choice of voltages to a heating or cooling system.

The photocell is mounted as shown in Fig. 1 and adjusted so that the light spot reflected on the ground glass scale of the potentiometer strikes the photocell when the instrument is near balance. The change in light is converted into a voltage variation that activates the relay, with no effect on the normal action of the galvanometer.

A convenient mounting is shown in Fig. 2. The cell is cemented into an adapter of suitable length and held in close contact with the scale by a length of spring steel. A ring of blotter paper is cemented over the end of the photocell to minimize the dimension of the light beam striking the cell.

†One source is the Allied Radio Corporation, 100 N. Western Ave., Chicago 80, Ill.

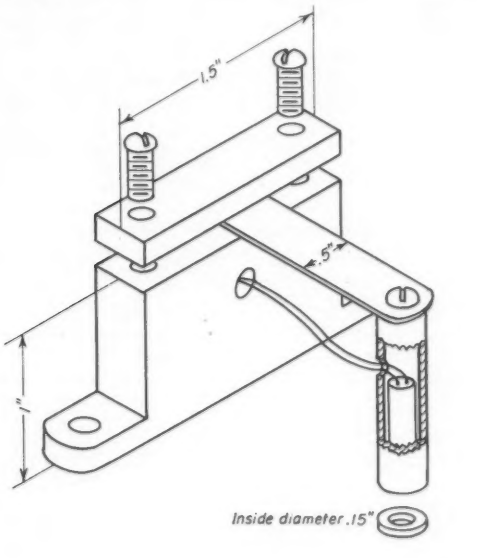


Fig. 2 Photocell mounting

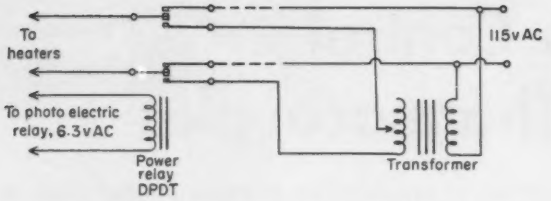


Fig. 3 Wiring diagram for power relay

The power relay is wired as shown in Fig. 3. The 115-volt leads to the relay contacts are not used when simple on-off operation is desired. When temperature is regulated by varying the voltage alternately from a high of 115 volts to a lesser value supplied by the transformer, the 115-volt connection is made as shown by the broken lines.

Accuracy

The accuracy of the regulator can be determined by placing the reference junction of a copper-constantan thermocouple in an ice bath and varying the slidewire resistance. At each movement of the relay armature the deflection can be read on the galvanometer scale. The average of ten such readings indicated an instrument differential of 0.042 F.

The upper curve of Fig. 4 shows results of a simple on-off application to control the temperature of a water bath. An insulated thermocouple junction was placed in the center of the bath. The voltage to an electric heater was adjusted to provide similar heating and cooling rates in the bath. Whenever the temperature varied by 0.021 F. from the instrument setting, the galvanometer activated the relay, turning the heater current on or off.

The lower curve of Fig. 4 charts performance in controlling the surface temperature of the soil in a greenhouse pot. A butt-welded 36-gauge thermocouple junction slightly smaller than the largest soil particles was placed between the soil particles on the surface. Three 250-watt infrared lamps supplied heat. Whenever the galvanometer indicator reached a point 0.15 F. below the temperature setting, the power relay switched the lamps from 115 volts to a lower voltage supplied by the transformer. The higher voltage was again switched on when temperature fell 0.192 F. below the setting. In this application it was not possible to adjust the heater output to attain similar heating and cooling rates. The lamps had a high output for 2 sec and a low output for 14.8 sec.

The sinusoidal curves represent the temperature at the thermocouple junction plus or minus inherent variations in the potentiometer. The vertical distance between *A* and *B* represents the instrument differential of 0.042 F. These curves are similar in most respects to those described by Reid(1). At point *A* the temperature has reached the upper limit of the instrument differential and the relay is opened. Because of the lag between the heater and the thermocouple the temperature continues to rise until the decrease in the heater output is felt at the junction. The temperature then falls to the lower limit of the instrument differential at *B* and the relay closes. The temperature continues to fall until it is again raised to *A* by the increase in heater output.

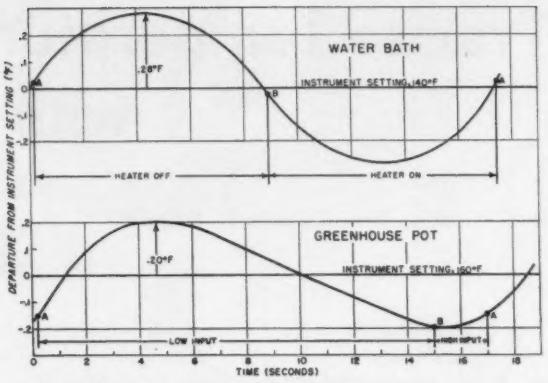


Fig. 4 Performance of regulator in controlling temperatures of a water bath and of the surface soil in a planting pot

References

1 Reid, W. T. An electronic-contacting galvanometer for temperature control. In Temperature, its measurement and control in science and industry. A record of a symposium held in New York, November 1939, under the auspices of the American Institute of Physics, pp. 611-616, 1941.

2 Roebuck, J. R. A sensitive flexible thermostat. Jour. Optical Soc. Amer. and Rev. Sci. Instruments 3:93-100, 1932.

3 Walsh, W. L. and Milas, N. P. A simple photoelectric thermoregulator. Jour. Indus. and Eng. Chem. Anal. Ed. 7:122-123, 1935.

. . . Compaction by Traffic

(Continued from page 400)

Soil Management Can Reduce Soil Compaction

Research can only identify and evaluate the importance of those factors which result from soil compaction. It then, however, falls upon others to use the facts appropriately. In the case of the disk harrow, it has been shown that a large force is applied to the soil over a small contact area. These forces are of sufficient magnitude that they may cause soil damage in the form of harrow soles. The disk harrow must then be used with caution to minimize any damage which would result from its use. This can only be done at the time of disking by the operator.

Soil Compaction Can Be Corrected

In view of the fact that soil compaction by traffic is increasing and since it already exists in many locations, certain things can be done to remove or minimize the ill effects of soil compaction: *(a)* Avoid travel on the soil under those conditions which are conducive to soil compaction. If it is absolutely essential that an operation be conducted, one should attempt to remove as much of the compaction by tillage, *i.e.* with tines which follow the offending wheels to loosen the compacted wheel paths. *(b)* Eliminate unnecessary tillage or traffic from the soil. It is important to realize that excessive tillage, which is not only expensive, may also be damaging to the soil. Obviously, the elimination of traffic must be balanced against other management considerations. *(c)* The use of new and improved equipment, which is designed with a specific aim of reducing soil compaction, will assist in reducing future soil compaction. *(d)* Proper management of the soil, which includes deep tillage to remove compacted layers in the soil and the use of deep rooted crops to help improve soil structure, is quite effective in overcoming some types of soil compaction. This type of management is generally as effective on dense soils which have been formed by traffic as it is to those dense soils which are formed genetically.

OFFICERS • COUNCIL • DIVISIONS • REPRESENTATIVES • COMMITTEES

American Society of Agricultural Engineers

1959-1960

OFFICERS AND COUNCIL

		Council term expires
L. H. Skromme	President	June 1961
L. W. Hurlbut	President-Elect	June 1962
W. J. Ridout, Jr	Vice-President	June 1960
J.W. Borden	Vice-President	June 1961
E. W. Schroeder	Vice-President	June 1962
G. E. Henderson	Councilor	June 1960
A. W. Cooper	Councilor	June 1961
H. H. Nuernberger	Councilor	June 1961
E. D. Anderson	Past-President	June 1960
E. G. McKibben	Past-President	June 1961

Central office of the Society
420 Main St.
St. Joseph, Michigan
Telephone: YUkon 3-2700

Jimmy L. Butt, Executive Secretary

Ralph A. Palmer,
Treasurer and Assistant Secretary

James A. Basselman,
Editor and Publisher

Harmon Mulbar,
Public Relations and Advertising Manager

CABINET

Includes: (1) Officers and Council; (2) Division Officers, (Chairman, Vice-Chairman, and Past-Chairman – and Chairman of Steering Committee); (3) Chairman of Meetings Committee; (4) Section Representatives (Chairman and Secretary)

NOMINATING COMMITTEE

R. K. Frevert, chairman

R. E. Stewart — Nolan Mitchell

C. S. Morrison — G. E. Spencer

PROFESSIONAL DIVISIONS – Executive Committees

Power and Machinery Division
H. F. Miller, Jr., chairman
K. K. Barnes, vice-chairman
C. B. Richey, past-chairman

Electric Power and Processing Division
C. W. Hall, chairman
H. J. Hansen, vice-chairman
D. L. Searls, past-chairman

Farm Structures Division
G. L. Nelson, chairman
H. J. Barre, vice-chairman
S. S. DeForest, past-chairman

Soil and Water Division
E. H. Kidder, chairman
D. D. Smith, vice-chairman
J. R. Carreker, past-chairman

Education and Research Division
E. T. Swink, chairman
S. M. Henderson, vice-chairman
G. E. Spencer, past-chairman

OFFICIAL ASAE REPRESENTATIVES ON COOPERATIVE ACTIVITIES

Engineers Joint Council (Observer) – W. J. Ridout, Jr.; Alternate, H. H. Nuernberger.

Engineers Joint Council Committees –

Committee on Employment Conditions – B. T. Virtue, T. W. Edminster

Engineering Manpower Commission – W. M. Carleton, H. E. Besley

Committee on International Relations – E. W. Tanquary, E. L. Barger

National Water Policy Panel – L. A. Jones, M. L. Nichols

Recognition of Specialties in Engineering – F. W. Peikert, W. J. Ridout, Jr.

Conference Committee, Sixth Nuclear Congress – D. E. Wiant, J. K. Jensen (Alternate)

Personnel for Inspection Committees, Accrediting Program, Engineers' Council for Professional Development – Roy Bainer, E. L. Barger, H. J. Barre, Hobart Beresford, D. G. Carter, W. H. Carter, E. H. Case, A. W. Cooper, Kyle Engler, A. W. Farrall, L. J. Fletcher, R. K. Frevert, L. W. Hurlbut, F. A. Kummer, F. B. Lanham, G. H. Larson, W. J. Liddell, A. D. Longhouse, K. L. Magee, J. W. Martin, Howard Matson, Geo. B. Nutt, F. W. Peikert, R. R. Poynor, J. Roberts, J. B. Rodgers, E. W. Schroeder, G. O. Schwab, A. B. Skromme, B. G. Van Zee, S. A. Witzel, W. H. Worthington, E. D. Anderson, J. D. Long, C. S. Morrison, Virgil Overholt, R. R. Owen, C. B. Richey, G. A. Rietz, L. H. Hodges, G. M. Eveleth, C. W. Bockhop, H. J. Hansen, E. W. Lehmann, E. G. McKibben.

National Fire Protection Association – Farm Structures: E. W. Foss, Henry Giese. Alternate, R. C. Swanson. Rural Electric: H. S. Pringle. Alternate, R. W. Kleis

Committee A5 (Corrosion of Iron and Steel), American Society for Testing Materials – Henry Giese (Iowa), H. A. Peterson (Pennsylvania), R. B. Furry (New York), L. H. Wilkes (Texas), L. W. Neubauer (California), A. C. Dale (Indiana)

Plan Committee, National Adequate Wiring Bureau–M. O. Whithed. Alternate, U. F. Earp

Technical Subcommittee, Industry Committee on Interior Wiring Design – M. H. Lloyd. Alternate, R. H. Brown

National Farm Electrification Conference – Price Hobgood. Alternate, E. T. Swink

Sectional Committee B18 (Bolt, Nut and Rivet Proportions), American Standards Association – R. C. Frevik. Alternate, E. E. Sands

Sectional Committee B29 (Transmission Chain and Sprocket Teeth), American Standards Association – K. M. Hickman. Alternate, E. A. Paul

Subcommittee on Home and Farm Freezers, Sectional Committee B38 (Household Refrigerators and Home and Farm Freezers), American Standards Association – D. C. Sprague

Sectional Committee K61, (Storage and Handling of Anhydrous Ammonia Solutions), American Standards Association – Douglas Johnston. Alternate, S. D. Pool

Sectional Committee, Y1 (Abbreviations); Y10 (Letter Symbols); Y32 (Graphical Symbols and Abbreviations), American Standards Association – J. A. Basselman. Alternate, R. A. Palmer

Sectional Committee Z59 (Fluid Permeation), American Standards Association – W. A. Raney. Alternate, Howard Haise

National Joint Committee on Fertilizer Application (ASA, ASHS, NCA, NPFI, FEI and ASAE cooperating) – J. W. Ackley, E. K. Bonner, Jr., V. A. Erickson, R. C. Frevik, W. F. Millier, J. L. Smilie, H. D. Wittmus, W. C. Hulburt, C. B. Adams, G. E. Fairbanks, C. M. Hansen

American Grassland Council (ADSA, ASAP, ASA, FEI, NASM, SSSA, and ASAE cooperating)–M. H. Barton. Alternate, C. W. McKeon

American Society for Engineering Education (Member of General Council) – G. E. Spencer. Alternate, F. B. Lanham

Agricultural Research Institute – E. W. Lehmann. Alternate, H. E. Pinches

American Association for the Advancement of Science (Member of Council) – M. E. Singley. Alternate, E. W. Walpole

Policy Committee, Professional Agricultural Societies – W. M. Carleton. Alternate, K. H. Norris

Inter-Society Committee on Soil Compaction (ASA, SSSA and the ASAE cooperating) – J. L. Diamond, G. E. Ryerson. Alternate, G. K. McCutcheon

Technical Advisory Committee on Plant and Animal Husbandry (Joint with American Society of Heating, Refrigerating and Air Conditioning Engineers) – R. E. Stewart (chairman), T. E. Bond, R. L. Givens, C. F. Kelly, G. L. Nelson, H. J. Thompson, R. G. Yeck

Joint Committee on Farm Lighting (IES and ASAE) – M. H. Lloyd (chairman), M. O. Whithed, J. P. Schaenzer, D. E. Wiant

National Academy of Sciences–National Research Council, Division of Biology and Agriculture – R. L. Green

COMMITTEES OF ASAE

STANDING COMMITTEES

Meetings Committee – B. J. Lamp, Jr. (chairman), H. F. Miller, Jr., E. H. Kidder, G. L. Nelson, C. W. Hall, E. T. Swink, C. W. Terry

Jury of Awards of Honor – I. D. Wood (chairman), E. W. Tanquary, G. B. Nutt, W. H. Worthington, Roy Bainer, E. D. Anderson, E. G. McKibben

Jury for the MBMA Award – J. F. Schaffhausen (chairman), W. V. Hukill, C. K. Otis, C. H. Jefferson, C. F. Kelly, F. J. Reynolds

Finance Committee – H. F. McColly (chairman), E. D. Anderson, F. A. Lyman, Lee Ford

Committee on Journal Paper Awards – J. E. Harmond (chairman), G. A. Karstens, (vice-chairman), T. O. Hodges, V. H. Baker, Howard Matson

Committee on Student Paper Awards – R. C. Evans (chairman), R. H. Tweedy, R. S. Palmer

Committee on FEI Trophies – F. E. Schlueter (chairman), W. L. Sprick, R. E. Wallin

Committee on Public Relations – (to be announced)

Committee on Student Branches – D. B. Brooker (chairman,) R. O. Martin, D. L. Jordin, R. E. Choate, F. J. Hassler

Committee on Engineering Registration – H. H. Nuernberger (chairman), J. H. Lillard, H. J. Barre, S. M. Henderson, M. J. Happe

SPECIAL COMMITTEES

Engineers' Classification in Civilian and Military Service – W. M. Carleton (chairman), T. E. Hienton (vice-chairman), F. P. Hanson, H. E. Besley, J. C. Dykes, H. J. Thompson

Committee on Technical Data – F. H. Buelow (chairman), N. A. Evans (vice-chairman), D. C. Kirk, W. A. Wathen, R. D. Miller, Guy E. Woodward, L. H. Lamouria, A. C. Dale, E. S. Holmes, H. A. Kramer

Committee on Farm Safety – R. E. Heston (chairman), C. L. Zink (vice-chairman), D. A. Kitchen, Martin Ronning, S. P. Lyle, E. D. Merrill, R. C. Swanson, B. T. Stephanson, R. R. Parks, W. C. Krueger, J. P. Schaenzer, K. V. D. Fiske, L. W. Knapp, E. W. Foss, V. S. Peterson

Committee on Instrumentation and Controls – K. H. Norris (chairman), Andrew Hustrulid (vice-chairman), Coby Lorenzen, G. S. Birth, W. A. Junnila, J. J. Kolega, H. W. Van Gerpen, E. C. Meyer, K. A. Jordan

ASAE Electric Utilization Research Conference Committee – W. J. Ridout, Jr. (chairman), R. R. Mauney (vice-chairman), E. T. Swink, Hobart Beresford, J. Roberts, J. P. Schaenzer, D. L. Searls, J. C. Cahill, M. B. Penn, H. H. Beaty, R. J. Gingles, H. S. Pringle, J. P. Ditchman, W. Floyd Keepers, L. J. Endahl, W. C. Wenner, Jr., B. C. Reynolds, Price Hobgood, M. O. Whithed

Committee on Radiation – D. E. Wiant (chairman), F. C. Jacob (vice-chairman), J. K. Jensen, K. H. Norris, V. H. Baker, Andrew Hustrulid, S. O. Nelson, R. C. Nicholas, M. G. Cropsey, Wm. Kalbfleisch, S. S. Grossman

Motion Picture Production Committee – L. W. Hurlbut (chairman), D. E. Kuska, D. O. Hull, R. L. Green, G. O. Woodward, M. L. Esmay, H. S. Pringle, E. T. Swink, T. J. Brevik, H. H. Beaty

Motion Picture Finance Committee – J. W. Borden (chairman), F. C. Walters, R. G. Morgan, J. T. Phillips, Jr., W. J. Ridout, Jr., D. L. Searls, A. J. Schwantes, A. W. Farrall, L. E. Bradley, T. K. Swearingen, R. H. Driftmier, E. W. Lehmann.

Membership Committee – R. J. Alpers (chairman), R. M. Magee, R. G. Morgan, W. H. Knight, Fred Venrick

Committee on Forward Planning – E. W. Lehmann (chairman), A. W. Farrall, W. H. Worthington, E. L. Barger, S. S. DeForest, E. D. Anderson, Roy Bainer, W. J. Liddell, G. B. Gunlogson, E. W. Schroeder, K. H. Beauchamp, R. W. Kleis

Farmstead Engineering Conference Committee – E. L. Hansen (chairman), E. D. Anderson, T. E. Bond, S. S. DeForest, C. W. Hall, M. W. Forth, K. H. Beauchamp

COMMITTEES – POWER AND MACHINERY DIVISION

Executive Committee – H. F. Miller, Jr., chairman
K. K. Barnes, vice-chairman
C. B. Richey, past-chairman

Steering Committee – A. B. Skromme (chairman), W. F. Buchele (program vice-chairman), E. A. Henningsen (membership vice-chairman)

Terms expiring June 1960 – R. F. Colwick, T. L. Coulthard, E. R. Johnson, John Strait

Terms expiring June 1961 – N. F. Andrews, R. D. Barmington, R. G. Curley, G. Y. Greene, H. N. Irvine, B. J. Lamp, Jr., R. E. Patterson, L. G. Reeser, T. C. Skinner, E. S. Smith, G. W. Steinbruegge

Terms expiring June 1962 – W. J. Adams, Jr., R. L. Erwin, B. S. Horne, L. F. Janssen, G. H. Larson, J. S. Norton, C. H. Thomas, J. A. Weber

Technical Committee – L. H. Hodges (chairman), Merlin Hansen (vice-chairman)

Terms expiring June 1962 – C. L. Baker (Massey-Ferguson), E. M. Brumbaugh (Case), W. W. Henning (IH), L. H. Lamouria (Univ. of Calif.), E. W. Tanquary (IH), E. W. Todd (Massey-Ferguson), J. H. Zich (Ford)

Terms expiring June 1963 – A. G. Buhr (Allis-Chalmers), J. P. Carr (John Bean), H. F. McColly (Mich. State Univ.), A. B. Skromme (Deere), D. E. Kuska (Oliver), R. P. Harbage (New Idea), Wilhelm Vutz (New Holland)

Terms expiring June 1964 – C. T. O'Harrow (Ford), C. W. Cannon (Allis-Chalmers), F. P. Hanson (Caterpillar), H. K. Dommel (Oliver), G. R. Free (ARS, USDA), L. A. Liljedahl (ARS, USDA)

Committee on Soil Compaction – E. R. Allred (chairman), W. J. Chancellor (vice-chairman), H. P. Bateman, M. G. Bekker, W. F. Buchele, A. W. Cooper, J. L. Diamond, T. W. Edminister, J. K. Jensen, J. W. Martin, M. L. Nichols, I. F. Reed, C. B. Richey, G. E. Ryerson, H. N. Stapleton, R. I. Throckmorton, Jr.

Committee on Fertilizer Application – J. W. Ackley (chairman), W. C. Hulburt (vice-chairman), C. B. Adams, E. K. Bonner, Jr., V. A. Erickson, G. E. Fairbanks, R. C. Frevik, C. M. Hansen, W. F. Millier, J. L. Smilie, H. D. Wittmus

Committee on Agricultural Chemical Application – M. L. Adams (chairman), Frank Irons (vice-chairman), W. E. Yates (vice-chairman for Subcommittee on Agricultural Aviation), N. B. Akesson (vice-chairman for Subcommittee on Program Planning and Publications), C. M. Hansen (secretary), C. F. Becker, J. P. Carr, W. Dickison, W. W. Funk, W. W. Gunkel, J. E. Henry, D. B. Horton, D. A. Isler, M. M. Mayeux, R. R. Owen, B. C. Reynolds, L. O. Roth, G. S. Sanders, O. B. Wooten, V. D. Young, I. L. Williams

Committee on Hay Pelleting – H. D. Bruhn (chairman), C. E. McKeon (secretary), A. M. Best, D. T. Black, W. M. Cade, S. S. DeForest, J. B. Dobie, K. L. Magee, M. E. McClellan, H. F. McColly, G. E. Pickard

Committee on Transport and Tractive Efficiency – A. W. Cooper (chairman), C. B. Richey (vice-chairman), C. L. Baker, M. G. Bekker, W. F. Buchele, W. J. Chancellor, P. J. Forrest, K. E. Hohnl, J. M. Hooper, I. F. Reed, J. W. Seiple, H. N. Stapleton, G. W. Steinbruegge, T. J. Thaden, R. L. Wann*, C. W. Cannon

COMMITTEES – SOIL AND WATER DIVISION

Executive Committee – E. H. Kidder, chairman
D. D. Smith, vice-chairman
J. R. Carreker, past-chairman

Steering Committee – J. R. Carreker (chairman), E. H. Kidder (vice-chairman), D. D. Smith (secretary)

Irrigation Group – L. R. Swarner (chairman) (1958-60), J. T. Phelan (vice-chairman), J. L. Wiersma (junior vice-chairman)

Hydrology Group – E. C. Buie (chairman) (1958-60), L. L. Harrold (vice-chairman), L. M. Glymph, Jr. (past-chairman)

Drainage Group – G. O. Schwab (chairman) (1959-61), E. W. Gain (vice-chairman) (1959-61), W. W. Donnan (junior vice-chairman)

Soil Erosion Group – J. J. Coyle (chairman) (1959-61), B. A. Jones, Jr. (vice-chairman) (1959-61), N. P. Woodruff (junior vice-chairman) (1959-61)

Public Lands and Public Works – C. L. Hamilton (representative)

Committee on Nomenclature (1958-60) – J. R. Davis (chairman) (1958-60), L. W. Herndon, E. W. Gain, W. D. Lembke, L. R. Swarner, E. R. Allred, R. Z. Wheaton, A. L. Sharp, H. E. Gray, R. P. Beasley

Committee on Public Lands and Public Works (1959-62) – C. L. Hamilton (chairman) 62, W. H. Berry 62, B. F. Kiltz 62, H. S. Thompson 62

IRRIGATION GROUP

L. R. Swarner, chairman

Committee on Sprinkler Irrigation (1958-60) – J. T. Thornton 60 (chairman), Gilbert Levine 60 (vice-chairman), Crawford Reid 60, F. W. Peikert 60, W. J. Liddell 60, J. F. Schrunk 60, J. L. Wiersma 60, C. H. Pair 60, W. F. Lytle 60

Committee on Surface Irrigation (1958-63) – J. A. Bondurant 61 (chairman), M. C. Jensen 60 (vice-chairman), V. S. Aronovici* 60, J. T. Phelan 60, W. A. Hall 60, P. D. Doubt 60, L. F. Lawhon 60, Dell Shockley* 60, V. E. Hansen 60

Committee on Specifications for the Installation of Concrete Irrigation Pipe (1958-61) – A. F. Pillsbury 61 (chairman), T. M. Quackenbush 61 (vice-chairman), M. L. Burgener 61, R. V. Thurmond 61, H. F. Peckworth 61, Ephraim Dyer, Jr. 61, Ernest Fortier* 61, L. F. Lawhon 61

Committee on Standards for Measuring Intake Rates of Soil for Irrigation System Design (1958-60) – W. W. Donnan 60 (chairman), N. P. Swanson 60 (vice-chairman), L. J. Erie 60, C. H. Pair 60, G. W. Eley 60, C. K. Mutchler 60, W. A. Raney 60, C. S. Slater 60, C. S. Taylor 60, V. C. Jamison* 60

Committee on Irrigation System Design for Mosquito Control Work (1958-60) – M. B. Rainey 60 (chairman). Committee on standby basis. Members will be added as needed.

Committee on Standards for Irrigation Wells (1958-62) – P. E. Schleusener 61 (chairman), M. W. Bittinger 62 (vice-chairman), K. B. Bowman 62, T. H. Quackenbush 62, V. M. Scott 61, Ervin Stahl 61, R. V. Thurmond 60, W. V. Wagner, Jr. 61, I. D. Wood 60, H. G. Haight 60, D. N. Blake* 60, G. F. Briggs* 60, Leslie Carloss, Jr.* 60, Kyle Engler 62

*Advisory only

DRAINAGE GROUP

G. O. Schwab, chairman

Committee on Drainage Research (1958-63) – Jan van Schilfgaarde 63 (chairman), F. R. Hore 60 (vice-chairman), W. W. Donnan 60, R. J. Winger, Jr. 61, Phelps Walker 62, N. A. Evans 62, G. O. Schwab 61

Committee on Specifications for Design and Construction of Tile Drains (1958-60) – W. A. Cutler 60 (chairman). This Committee on standby basis. Members will be added as needed.

Committee on Surface Drainage (1958-62) – H. D. Haynes 62 (chairman), Phelps Walker 62 (vice-chairman), K. H. Beauchamp 60, I. L. Saveson 60, G. B. Fasken 61, L. F. Hermsmeier 61, L. W. Herndon 61, R. L. Green 62, R. L. Phillips 62

Committee on Drainage of Irrigated Lands (1958-61) – R. J. Winger, Jr. 61 (chairman), J. N. Luthin 61 (vice-chairman), James Turnbull 60, E. A. Olafson 60, N. A. Evans 62, W. H. Hedges 63, V. I. Myers 63

Committee on Inter-Relations of Highway and Agricultural Drainage (1958-60) – H. N. Luebcke 60 (chairman), Virgil Overholt 60 (vice-chairman), G. B. Pasken 60, R. J. Patronsky 60

Committee on Pump Drainage (1958-61) – C. L. Larson 61 (chairman), K. L. Klingelhofer 61, R. L. Green 60, K. V. Stewart 61, J. C. Stephens 60, G. B. Fasken 61, R. W. Irwin 60, Virgil Marvin 61, D. O. Hull 60

Committee on Materials and Materials Handling (1959-62) V. I. Myers 61 (chairman) (Members to be listed later)

SOIL EROSION GROUP

J. J. Coyle, chairman

Committee on Terrace Systems (1958-61) – Paul Jacobson 61 (chairman), R. P. Beasley 61 (vice-chairman), L. B. Worley 61, V. L. Hauser 61, P. M. Price 61, E. D. Butler 61

Committee on Conservation Tillage Methods (1958-61) – J. A. Allis 61 (chairman), G. R. Free 61 (vice-chairman), W. H. Lowry 60, A. P. Barnett 60, C. K. Mutchler 61, L. F. Hermsmeier 61

Committee on Erosion Control Research (1958-63) – L. D. Meyer 61 (chairman), H. D. Wittmus 63 (vice-chairman), A. P. Barnett 61, G. R. Free 60, N. P. Woodruff 61, M. C. Jensen 60

HYDROLOGY GROUP

E. C. Buie, chairman

Committee on Infiltration (1958-63) – H. N. Holtan 61 (chairman), H. P. Johnson 63 (vice-chairman), G. W. Eley 61, L. D. Meyer 62, L. A. Wakeman 63, P. J. Zwerman 62

Committee on Runoff (1958-63) – A. L. Sharp 61 (chairman), F. C. Mohler 63 (vice-chairman), A. R. Chamberlain 63, J. S. Mathews 62, D. C. Ralston 63, R. V. Keppel 63, A. P. Barnett 61, L. L. Kelly 62, W. O. Ree 61, P. D. Doubt 62

Committee on Evapo-Transpiration (1958-63) – W. O. Pruitt, Jr. 61 (chairman), J. C. Stephens 63 (vice-chairman), Gilbert Levine 62, P. E. Schleusener 62, J. W.

*Advisory only

Wolfe 63, T. V. Wilson 63, H. F. Blaney 61, L. L. Harrold 61, B. B. Bryan 63

Committee on Water Treatment and Use (1958-61) – T. L. Willrich 61 (chairman), J. W. Rockey 61 (vice-chairman), G. O. Schwab 61, T. O. Hodges 61, E. R. Daniel 61, F. B. Wright 61

Committee on Watersheds (1959-64) – H. M. Kautz 62 (chairman), O. W. Chinn 62, N. E. Leach 62, M. M. Culp 62, W. H. Berry 62

COMMITTEES – FARM STRUCTURES DIVISION

Executive Committee – G. L. Nelson, chairman
H. J. Barre, vice-chairman
S. S. DeForest, past-chairman

Steering Committee – W. E. Eakin (chairman), A. H. Schulz (vice-chairman), M. L. Burgener (secretary)
Terms expiring June 1960 – A. C. Dale, L. L. Boyd, C. K. Otis
Terms expiring June 1961 – Leland Bradley, H. C. Smith
Terms expiring June 1962 – B. F. Parker, D. W. Richter, L. L. Sammet, A. A. Zander

Committee on Animal Shelter Ventilation (Joint with Electric Power and Processing Division) – H. J. Hansen (chairman), W. F. Millier (vice-chairman), D. W. Bates, T. E. Bond, R. J. Bugbee, M. L. Burgener, M. H. Lloyd, Nolan Mitchell, C. D. Spates, F. P. Stephan, H. R. Wakefield, H. V. Walton, R. G. Yeck

Committee on Farm Fence Construction Standards – J. S. Boyd (chairman), W. A. Stacey (vice-chairman), P. G. Strom, E. D. Merrill, R. C. Handley, G. E. Henderson, H. N. Luebcke

Committee on Farm Building Construction Standards – N. H. Curry (chairman), A. A. Zander (vice-chairman), J. H. Pedersen (secretary), M. L. Burgener, J. W. Layer, A. C. Dale, D. V. Doyle, Walter Grub, F. J. Hanrahan, E. B. Moysey, L. W. Neubauer

Committee on Farm Structures Research Needs and Statistics – S. A. Witzel (chairman), E. G. Bruns (vice-chairman), C. H. Reed, G. T. Facer, Tappan Collins, F. G. White, W. H. M. Morris, C. E. Hervey, W. G. Kaiser, Robert Rowe, B. C. Reynolds

Committee on Farm Materials Handling (Joint with Electric Power and Processing Division) – C. K. Otis (chairman), B. A. McKenzie (vice-chairman), Marvin Nabben, F. L. Herum, R. M. George, C. A. Rollo, M. W. Forth, W. H. Yaw, G. L. Hazen, R. P. Prince, Robert Whitaker, Don Shimon, Thayer Cleaver, E. C. Schneider

COMMITTEES – ELECTRIC POWER AND PROCESSING DIVISION

Executive Committee – C. W. Hall, chairman
H. J. Hansen, vice-chairman
D. L. Searls, past-chairman

Steering Committee – C. W. Hall (chairman), H. J. Hansen (vice-chairman)
Terms expiring June 1960 – K. L. McFate, J. B. Stere, Frank Andrew, W. H. Knight
Terms expiring June 1961 – H. H. Beaty, M. B. Penn, L. J. Endahl
Terms expiring June 1962 – J. L. Calhoun, Price Hobgood, Elwood Olver, K. H. Norris
Terms expiring June 1963 – S. M. Henderson, J. H. Oliver, R. W. Kleis
Terms expiring June 1964 – G. W. Isaacs, E. L. Watson, J. H. Thomas, M. W. Gordon

Program Committee – G. W. Isaacs (chairman), L. J. Endahl, D. L. Searls, H. S. Pringle, H. J. Hansen, H. H. Beaty, J. W. Sorenson, Jr., C. E. Worlan, S. H. Booker, C. W. Shanks, C. W. Hall

Committee on Bulk Milk Cooling Systems – C. N. Turner (chairman), M. C. Ahrens, L. F. Charity, D. C. Sprague, A. K. Gillette, R. A. Keppeler

Committee on Farm Wiring – H. S. Pringle (chairman), M. H. Lloyd, G. P. Barrington, U. F. Earp, M. O. Whithed

Committee on Farm Materials Handling (Joint with Farm Structures Division) – C. K. Otis (chairman), B. A. McKenzie (vice-chairman), W. H. Yaw, G. L. Hazen, Marvin Nabben, M. W. Forth, R. P. Prince, F. L. Herum, R. M. George, C. A. Rollo, Robert Whitaker, Don Shimon, Thayer Cleaver, E. C. Schneider

Committee on Animal Shelter Ventilation (Joint with Farm Structures Division) – H. J. Hansen (chairman), W. F. Millier, M. L. Burgener, R. J. Bugbee, F. D. Stephen, H. V. Walton, H. R. Wakefield, T. E. Bond, Nolan Mitchell, M. H. Lloyd, D. W. Bates, C. D. Spates, R. G. Yeck

COMMITTEES – EDUCATION AND RESEARCH DIVISION

Executive Committee – E. T. Swink, chairman
S. M. Henderson, vice-chairman
G. E. Spencer, past-chairman

Steering Committee – E. T. Swink (chairman), S. M. Henderson (vice-chairman), G. E. Spencer (past-chairman)
Representation –
Committee on Extension – C. N. Hinkle (chairman), R. L. Maddex (vice-chairman), D. W. Derber (Industry rep.) E. D. Markwardt (Public Service Rep.)
Research Committee – R. E. Stewart (chairman), C. S. Morrison (vice-chairman), R. L. Erwin (Industry rep.), W. M. Carleton (Public Service rep.)
Curriculum and Course Content Committee – W. J. Promersberger (chairman), U. F. Earp (vice-chairman)
Graduate Studies Committee – F. J. Hassler (chairman), Andrew Hustrulid (vice-chairman)
Vocational Agricultural Teacher Training Committee– V. J. Morford (chairman), J. W. Matthews, (vice-chairman)

Committee on Research – R. E. Stewart (chairman), C. S. Morrison (vice-chairman)
Industry – H. J. Barre, E. W. Lehmann†, C. S. Morrison, E. A. Silver, R. N. Roth, R. L. Erwin, R. R. Poynor
Public Service – H. E. Pinches, W. M. Carleton, C. W. Hall, G. W. Giles, Chas. N. Hinkle, K. H. Norris, L. A. Liljedahl

Committee on Vocational Agriculture Teacher Training – V. J. Morford (chairman), J. W. Matthews (vice-chairman), M. M. Jones, A. A. Stone, A. H. Hollenburg, J. P. Schaenzer, R. P. Marvin, C. E. Johnson, E. W. Foss, R. N. Craig, R. E. Davenport, G. E. Henderson, J. M. Fore (**Advisory group** – Frank Anthony‡, H. W. Kitts‡, David Hartzog‡)

Committee on Graduate Instruction – F. J. Hassler (chairman), Andrew Hustrulid (vice-chairman), F. H. Buelow, R. R. Poynor, S. O. Nelson, Herman Bouwer, H. E. Pinches, F. T. Wratten

Committee on Curriculum and Course Content – W. J. Promersberger (chairman), U. F. Earp (vice-chairman), R. W. Kleis, J. B. Rogers, E. R. Allred, Price Hobgood, D. T. Kinard

Committee on Extension – C. N. Hinkle (chairman), R. L. Maddex (vice-chairman), E. D. Markwardt (past-chairman)
Terms expiring June 1960 – J. P. Schaenzer, D. L. Maxwell, G. O. Woodward
Terms expiring June 1961 – L. T. Wendling, Jr., D. R. Burrowbridge, D. G. Jedele, W. A. Jones, D. O. Hull
Terms expiring June 1962 – J. L. Calhoun, E. A. Olson, W. E. Eakin, D. P. Brown
Terms expiring June 1963 – R. O. Gilden, R. G. Curley, W. T. Welchert, N. T. Brenner
Terms expiring June 1964 – W. L. Griebeler, K. A. Koch, W. J. Liddell, D. N. Stiles, B. P. Hess

---

†ASAE Representative to Agricultural Research Institute, National Academy of Science – National Research Council
‡Non-member ASAE

J. B. Kelley, *(left)* professor of agricultural engineering, University of Kentucky, and recently elected to grade of Life Fellow of ASAE, was presented with a membership certificate by Dr. E. G. McKibben, president of ASAE, during recent meeting of Kentucky Section of ASAE. Proud witness is Mrs. Kelley

FEI Conducts Industry-Research Conference

Agricultural engineers from throughout the country attended a two-day industry-research conference at Purdue University May 27 to 29 to learn about recent engineering research in their field.

Dr. Earl L. Butz, Purdue's dean of agriculture, welcomed the group and G. E. Spencer, head of agricultural engineering department, presided during the opening session which was devoted to feed handling and storage.

A trio of Purdue agricultural engineers, B. A. McKenzie, I. J. Ross and G. W. Isaacs, discussed subjects ranging from farmstead mechanization to developments in air-tight grain storage. Crops and livestock, an engineering challenge, was the theme of the May 28 morning session. A. C. Dale, Purdue agricultural engineer, presided.

W. H. Yaw, Farm Clinic of the United States, Lafayette, was featured speaker at the luncheon, and Dr. E. G. McKibben, president of ASAE, addressed the banquet on May 28.

Research on tractors and field machines was the theme of the May 29 morning session. George Pickard, University of Illinois agricultural engineer, presided. Speakers included ASAE members J. P. Raney, Purdue; William A. Stout, Michigan State; and J. B. Liljedahl, Purdue. Reports covered subjects ranging from tractor seating comfort to tomatoes bred for machine harvesting.

New Scholarships at North Carolina State College

Three new agricultural engineering scholarships have been announced at North Carolina State College. Two valued at $200.00 each were established by the North Carolina Section of ASAE and are made possible by contributions from the Section members. The third is a "Special Name" scholarship in agricultural engineering recently established at North Carolina State College by the Surtman Foundation of Charlotte, North Carolina, by J. R. Surtman of the Carolina Ford Tractor Co. representing the foundation.

Recipients of these scholarships are selected by a Departmental Scholarship Committee and by the head of the agricultural engineering department. Selections are made on the basis of past accomplishments, aptitudes and need of financial assistance. The 1959-60 recipients are Clemon E. Bass, Jr., incoming freshman from Edenton, and Robert Cooke, rising junior from Huntersville. Winner of the Surtman Foundation Scholarship was Shelton Adcock, rising junior from Hendersonville.

AE Student

Word has been received that Delbert W. Fitzsimmons, ASAE student member, has graduated with high honors and placed at the top of the class of 900 seniors from the University of Idaho with a grade point average of 3.98. During three years at the University he received one hour of "B", and is the first agricultural engineering student to qualify as top student at the University.

Feed Production School and Small Mill Short Course

The 10th Annual Feed Production School including a Small Mill short course will be held September 23 to 26 at the Continental Hotel, Kansas City, Mo. Pelleting will be featured and the program will include roughage pelleting, pelleting complete rations, and related pelleting subjects, as well as other pertinent subjects of interest. For additional information write to: Feed Production School, Inc., 20 West Ninth Street Bldg., Room 410, Kansas City 5, Mo.

(Continued on page 410)

(Above) Principals in planning FEI Industry-Research Conference held at Purdue University *(left to right)* J. B. Liljedahl, associate professor of agricultural engineering, Purdue University; C. L. Dickinson, director of research, FEI; and F. P. Hanson, chairman of FEI research committee

(Left) W. H. Yaw, luncheon speaker at the conference, spoke on a balanced "agribusiness" program for small towns and farming areas

C. J. Scranton

R. P. Harbage

C. E. Seitz

Charles J. Scranton, general development engineer at the Allis-Chalmers Mfg. Co., LaPorte (Ind.) Works, has retired after 25 years of service with the company, and a lifetime career in the farm equipment field, starting with his graduation from Bradley Polytechnic Institute, now Bradley University, at Peoria, in 1912. He joined the company in 1934 as chief engineer of the LaPorte Works, and served in that capacity until 1957 when he was appointed to the position of general development engineer. His achievements have won national recognition for him. In 1952, he received the Cyrus Hall McCormick Gold Medal Award from ASAE, and, in 1957, he was presented with the Farm Equipment Institute's Gold Merit Award. He will continue to reside in LaPorte, and, after a short rest, plans to travel.

Robert P. Harbage, formerly an engineering supervisor, has been promoted to the newly established post of administrative assistant to the director of engineering at New Idea Division of Avco Corp., Coldwater, Ohio. Prior to joining the company in 1956, he was employed by Procter and Gamble in connection with the development of packaging machinery. Mr. Harbage also has been associated with the New Holland Machine Co., where he worked with field and laboratory stress analysis problems and later became a design engineer. He served as chairman of the Ohio Section of ASAE in 1958.

Charles E. Seitz, former professor of agricultural engineering, Virginia Polytechnic Institute, a native of the state of Nevada and an alumnus of the University of Nevada, has recently received the citation of "Distinguished Nevadan" by the University. The citation is given in recognition of his significant achievement contributing to the economic and scientific advancement of his state and nation, and for exceptional service to the well being of mankind. Mr. Seitz was president of ASAE in 1932-33 and has been a member of the Society since 1917. Announcement of his election to the grade of Honorary Member in the Society appeared in the May issue of AGRICULTURAL ENGINEERING.

Thomas T. Pedersen, a graduate student in agricultural engineering at Michigan State University, has returned to Copenhagen, Denmark. In his native country of Denmark, he is an assistant professor in agricultural engineering at the Royal Veterinary and Agricultural College.

A. L. Schriml has been named product sales manager for the new line of poly-V drives at Dayton Industrial Products Co., a division of The Dayton Rubber Co. Mr. Schriml joined the company in 1936 and has handled several engineering and sales assignments. Since 1949 he has been working out of the company's Chicago office.

H. Eugene Nielsen, partner in the firm of Nielsen, Reeve and Maxwell Inc., Consulting Civil Engineers, recently announced the opening of a new office in the Washington Terrace Administration Building, 275 East 4425 So., Washington Terrace, Utah. This firm also maintains an office in Bountiful, Utah.

Dale W. Turnbull, district representative, Caterpillar Tractor Co., Tulsa, Okla., advises that he has been offered a promotion to supervisor of the Wheel Tractor and Motor Grader Section of Sales Development, and will soon be moving to Peoria, Illinois.

Walter W. Hinz advises that he has accepted an Overseas Mission to Kingston, Jamaica, with the International Cooperation Administration. He formerly was connected with Miller & Poston Mfg. Co. at Spokane, Wash.

Richard J. Rowe has recently changed positions from agricultural engineer, Agricultural Research Service, USDA, Iowa State College, to assistant agricultural engineer and assistant professor, agricultural engineering department of the University of Maine.

Richard W. Smith has been transferred from the Chicago office of The Fafnir Bearing Co. to the company's Main Plant at New Britain, Conn. He will continue to serve in the sales department at the new location.

Dale L. Woolsoncroft, who was territory manager, Tractor and Implement Division, Ford Motor Co., Ames, Iowa, is now owner and manager of Woolsoncroft Implement, a dealership, in Ames, Iowa.

Alton G. Levorson reports that he is on home-leave from his U.S. Overseas Mission to Bolivia. Upon completion of his leave, he expects to be assigned to Saigon, Vietnam, where he will be connected with land development, clearing, etc., for the settling of displaced persons.

William C. Fairbank, formerly extension assistant at the Agricultural Extension Service in Woodland, Calif., advises he is now with the Agricultural Engineering Dept. of the University of California, Davis, as an extension engineering technologist. Previous to his work at the Agr. Extension Service he was plant engineer for Bercut-Richards Packing Co. in Sacramento, Calif. and also has been connected with Food Machinery & Chemical Corp. in San Jose, Calif. as an application engineer.

ASAE MEETINGS CALENDAR

September 1-3 — NORTH ATLANTIC SECTION, University of Maryland, College Park, Md.

October 2-3 — KENTUCKY SECTION, Mammoth Cave, Ky.

October 14-17 — PACIFIC NORTHWEST SECTION, Ephrata, Wash.

October 22-23 — ALABAMA SECTION, Enterprise, Ala.

October 24 — MICHIGAN SECTION, Michigan State University, East Lansing.

December 16-18 — WINTER MEETING, Palmer House, Chicago, Ill.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

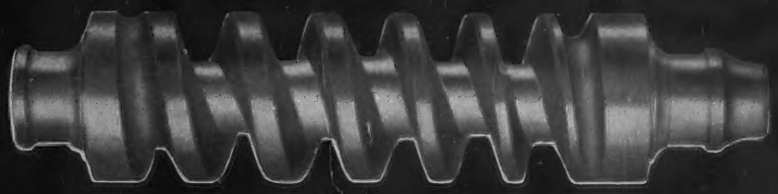
NECROLOGY

Dalton G. Miller, consulting engineer and 1948 ASAE John Deere Gold Medalist, passed away on June 26, 1959, in St. Paul, Minn. He had been ill during the past year with a heart weakness that caused a gradual decline in his general health. Born May 7, 1880, at Guthrie Center, Iowa, Mr. Miller obtained his high school training in the city of his birth. He was graduated from the University of Iowa in 1905 with a B.S. degree in civil engineering, and in 1924 was given the C.E. degree by the same institution. In October 1906 he received an appointment in the U.S. Department of Agriculture and served continuously in the Department, until his transfer, July 16, 1946, to the Public Roads Administration. He started work in U.S.-D.A. with the Division of Irrigation and Drainage, following its organization migrations from the Office of Experiment Stations, through the Bureau of Public Roads, of Agricultural Engineering and its successor alignments to the Soil Conservation Service. Since 1921 he has been a resident of St. Paul, Minn., where he has been assigned to work in cooperation with the department of agricultural engineering, University of Minnesota.

D. G. Miller

Mr. Miller was considered an authority in his field and earned the respect and cooperation of the portland cement industry and of related agencies for his work on the action of soil waters on concrete. His membership in the ASAE dates back to 1925. He is survived by his wife, Cecelia, three sons, Dalton Giles, Jr., Fredrick, and Curtis, and one daughter, Cecelia.

VARIABLE* RATIO STEERING



Constant ratio 22:22:22 . . . 22 to 1 ratio for cornering and 22 to 1 for straight-ahead handling . . . 5 turns of wheel from lock to lock.

Variable ratio 12:20:12 . . . 12 to 1 ratio for cornering and 20 to 1 for straight-ahead handling . . . 3 turns of wheel from lock to lock.

*Originated and developed by Ross . . . .

● Today, the big news in steering is *variable ratio* steering.

And with good reason. Variable ratio steering gives *faster* steering and quicker recovery for cornering . . . and *slower* steering and greater stability for straight-ahead handling. Variable ratio is a Ross development.

Steering specialists since 1906, Ross provides the right gear for every steering need—manual or power, constant or variable ratio. Ross invites *your* steering inquiry.

Ross STEERING

ROSS GEAR AND TOOL COMPANY, INC. • LAFAYETTE, INDIANA

Gemmer Division • Detroit

A. W. Farrall

Agricultural Engineering Departments Exceed Motion Picture Quota

A. J. Schwantes

THE first major category to exceed its quota in raising funds for the ASAE motion picture was the one designated as "Colleges with Agricultural Engineering Departments."

The quota set for this fund-raising category was $5,000. To date, 23 agricultural engineering departments have submitted purchase orders, or given firm letters of intent to purchase copies of the motion picture at $250 each — total, $5,750. Several departments are still to be heard from, and there is likelihood that this oversubscription of quota will be further extended in the weeks ahead.

Heading the drive for funds in this category were A. W. Farrall, head of the agricultural engineering department, Michigan State University, and A. J. Schwantes, head of the agricultural engineering department, University of Minnesota. The committee co-chairmen directed a series of letters to agricultural engineering departments with the excellent response described above.

Purchase of a copy of the film by an agricultural engineering department assures the availability of one copy of the film to that institution on a permanent basis. It should be noted that while the above commitments represent firm orders for prints of the film, actual cash from this effort will not be available until finished copies of the film are delivered.

Funds and commitments from the ASAE sections category are coming in at a good rate as are contributions from selected ASAE members. Contacts for the industry quota of the finance committee budget are being initiated at the present time. Full information concerning the various fund-raising categories was carried in the January 1959 issue of AGRICULTURAL ENGINEERING.

. . . News

(Continued on page 407)

Short Course on Statistical Methods

A special short course on Statistical Methods will be offered for research workers in industry and the physical sciences Aug. 10 to 15 at Brevard College in Brevard, N. C. Both introductory and advanced sections will be conducted by the North Carolina State College Institute of Statistics and the College Extension Division. Five members of the college's Institute of Statistics will instruct the short course. All five have had many years of teaching, research, and consulting experience. Registration will be limited to 50 students for each section. For further information or registration, write the College Extension Division, Box 5125, State College Station, Raleigh, N. C.

EVENTS CALENDAR

August 9-12 — The 31st annual summer session of the *American Institute of Cooperation,* University of Illinois, Urbana, Ill. Details may be obtained from the Extension Service, College of Agriculture, University of Illinois, Urbana, Ill.

August 24-29 — *International Association for Hydraulic Research Eighth Congress,* Montreal, Canada. For information write to Leo Roy, c/o Quebec Hydro-Electric Commission, 107 Craig St. West, Montreal 1, P.Q., Canada.

August 26-28—*Fourteenth Annual Meeting* of the *Soil Conservation Society of America,* Rapid City, S.D. For details contact Soil Conservation Society of America, 838 Fifth Ave., Des Moines 14, Iowa.

September 14-17 — *SAE National Farm, Construction and Industrial Machinery Meeting,* Milwaukee Auditorium, Milwaukee, Wis. Write to Society of Automotive Engineers, Inc., 485 Lexington Ave., New York 17, N. Y.

September 28 - October 1 — *The American Welding Society* fall meeting, Sheraton-Cadillac Hotel, Detroit, Mich. AWS headquarters at 33 W. 39th St., New York 18, N. Y., may be contacted for further details.

September 28 - October 2 — *National Hardware Show,* The Coliseum, New York City. Additional information may be obtained from NHS executive offices, Suite 1103, 331 Madison Ave., New York 17, N. Y.

October 8-10 — *Mid-American Lawn, Garden & Outdoor Living Trade Show,* International Amphitheatre, Chicago. Complete data and floor plans are available from the Mid-America Lawn, Garden & Outdoor Living Trade Show, 331 Madison Ave., New York 17, N. Y.

October 11-14 — *Farm Equipment Institute* 1959 Convention, Queen Elizabeth Hotel, Montreal, Quebec, Canada. Write to FEI, 608 S. Dearborn St., Chicago 5, Ill., for further details.

October 19-22 — *National Retail Farm Equipment Association's* Annual Convention, Philadelphia. Contact National Retail Farm Equipment Association, 2340 Hampton Ave., St. Louis 10, Mo., for details.

November 18-20 — Sixth Annual *National Electric Farm Power Conference,* Westward Ho Hotel, Phoenix, Ariz. For additional information write to Inter-Industry Farm Electric Utilization Council, Inc., P.O. Box 577, Washington 4, D.C.

Steering Committee for Education and Research Division Organized

Chairman Earl Swink of the E & R Division has announced the organization of a Steering Committee for the Division consisting of representatives of Research, Extension and Teaching. Representatives are given in the ASAE committee organization list carried in this issue, as appointed by President Skromme.

The new Steering Committee will be made up as follows:

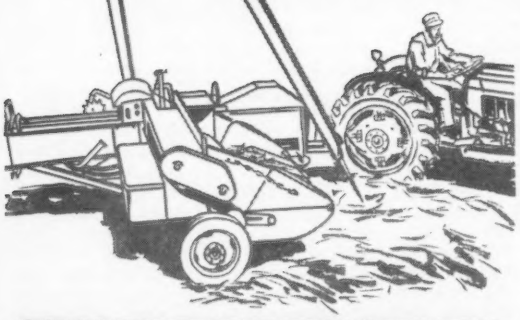
(1) Division Executive Committee (chairman, vice-chairman, past-chairman)
(2) Extension representation (committee chairman, vice-chairman, industry representative, public service representative)
(3) Research representation (committee chairman, vice-chairman, industry representative, public service representative)
(4) Curriculum and Course Content representation (committee chairman, vice-chairman)
(5) Graduate Studies representation (committee chairman, vice-chairman)
(6) Vocational Agricultural Teacher Training representation (committee chairman, vice-chairman)

This will give a total of 17 persons on the committee which will be presided over by the Division Chairman.

The new committee will bring the teaching, research and extension functions together into a unified divisional organization representing the interests of both public service and private industry. None of the present activities of the various committees will be curtailed in any way, and it is anticipated that the new organizational setup will result in better representation of the interests of all these functions through the recently authorized E & R Division representative to the Council, the general session program of our winter meeting, and broader support for the resolutions, policies, and programs advanced by any single group.

Buy a Rollway

engineered to your needs . . . Margins of safety are important, of course. But quality and precision unused and unusable over the life-expectancy of the implement are wasteful. That's why each Rollway implement bearing is engineered for the specific range of loads, speeds, maintenance and storage normally encountered in the machinery for which it is designed. For example . . . .



Split Sleeve Bearing Makes Simplicity Pay

Simple, practical in design, the bearing picture above gives you a *choice* of "life expectancies", for it is available: 1. Unhardened and unground; 2. Hardened and unground; 3. Hardened and ground. To assemble, simply press the sleeve in housing at unit-assembly bench, then slide the bearings on shaft at the group assembly station. Fast . . . easy . . . less costly!

ROLLWAY®
BEARINGS
COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

Free Engineering and Metallurgical Counsel

Let us examine your bearing problems in a consultation with your engineers to see how the wide range of Rollway Bearings can cut costs and improve the usable performance of your implements. No cost. No obligation.

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

. . . Engineering in Agriculture

(Continued from page 385)

tion of trucks. Agriculture uses annually the products from between 15 and 20 billion gallons of crude petroleum; this is more than any other industry and more than one-fourth of the total domestic production.

The total horsepower of farm tractors alone is estimated at over 120 million, more than twice that of all railway locomotives. *Between 30 and 40 mechanical or electrical horsepower is available for each farm worker.*

Further challenges of agriculture to engineers interested in power are the problems of arranging for the effective and economic use of solar energy and the development of methods and means for the direct or indirect use of atomic energy in agricultural operations and processes.

Agriculture—Men

From the standpoint of the utilization of *men*, agriculture also offers a real challenge. In spite of the fact that our agriculture leads the world in labor efficiency, we still have in round figures eight million farm workers, about one-eighth of the nation's work force. This is nearly half as many as are employed in all manufacturing enterprises. The average investment per worker is higher for agriculture than for all manufacturing. It averages about $18,000. For many commercial farms it is more than double this and for certain types of farms over large areas it is $50,000 to $100,000 or more.

Agriculture—Customer

From the standpoint of agriculture's relation to the rest of the national economy it should be noted that annual purchases of materials and services for agricultural production are between 16 and 20 billion dollars. Thus agriculture as an industry is a 50-million-dollar-a-day customer. This is six times as much as the railway system proudly advertises.

Agriculture—Working Conditions

As a final engineering challenge, agriculture offers probably the most difficult and varied combinations of working conditions of any major industry. These include *(a)* widely dispersed locations, *(b)* seasonal operation, *(c)* non-uniform raw materials, *(d)* moving operation over rough terrain and varying soils, and *(e)* operation under extreme variations of moisture and temperature. Engineering for many manufacturing and other industrial operations is relatively simple compared to engineering for agriculture.

So much for the defense, for an attempt to document the fact that there is "engineering in agriculture," that the terms "engineering" and "agriculture" are not incompatible and that the term "agricultural engineering" is in fact a reasonable combination and not a semantic paradox.

The World Challenge

What about agricultural engineering outside of the United States? Each year—in fact, we can almost say each day—the world becomes relatively smaller. Agricultural engineering in the rest of the world will become increasingly important to American agricultural engineers. It should be noted that in the latest ASAE membership roster of more than 5,000 members, nearly 500, approaching 10 percent, have addresses outside the United States. These members represent every continent, except the Antarctic, nearly 300 geographic locations, and between 50 and 60 nations, depending upon one's definition of a nation.

An international directory of agricultural engineering institutions* has been compiled by H. J. Hopfen, farm implement specialist, Land and Water Use Branch, Agricultural Division, Food and Agricultural Organization of the United Nations. This directory lists government institutions and services in the field of agricultural engineering for 74 nations. It is worth noting that outside the USA and USSR there appear to be between 120 and 150 important research locations. The listings for the USSR are not very detailed; thus it is difficult to judge which are engaged in serious research. However, the USSR listings cover 19 pages and indicate agricultural engineering agencies at 65 geographic locations.

The three of us from the Agricultural Engineering Research Division of the U.S. Department of Agriculture who attended the International Congress of Agricultural Engineering at Brussels last summer visited outstanding agricultural engineering research agencies in England, Germany, Holland, Denmark and Sweden. We were very favorably impressed by those we visited, and there are many other agricultural engineering research agencies in the British Isles and Europe, some of them equally or even more important, particularly in certain special phases of agricultural engineering research.

All stations visited are doing important basic work. Our American agricultural engineering research workers should be better informed on the research being conducted at these stations. It is probable that almost every problem being studied by the USDA Agricultural Engineering Research Division, by any agricultural engineering department of any state experiment station, or by the research divisions of most commercial companies, is being seriously investigated by one or even several of the agencies listed in the FAO directory.

All of the research agencies we visited are doing much more than we are to make available translations of agricultural engineering research reports of other nations. For example, the National Institute of Agricultural Engineering of England has a scientific intelligence unit of six full-time workers. This unit is able to review and translate literature in the Romance languages, German and Scandinavian languages and Russian, and publishes quarterly the "Agricultural and Horticultural Engineering Abstracts" with which many of you are familiar. As an example of the coverage of this publication, the fourth-quarter 1958 issue contained 336 abstracts. These abstracts included 18 German articles, 8 German machine tests, 17 Swedish machine tests, 12 Danish machine tests, 11 Finnish machine tests, 3 Norwegian machine tests and 1 Norwegian article, 3 French articles and 3 Hungarian articles.

*Columbia University Press, International Documents Service, 2960 Broadway, New York 27, New York; price $1.00.

ASAE Executive Secretary J. L. Butt informs me that more than 1500 copies of AGRICULTURAL ENGINEERING go to addresses outside of the United States. We have all heard of the extent to which Russia is translating world literature in all fields of science and engineering. Nearly 200 of these 1500 copies of AGRICULTURAL ENGINEERING which go to addresses outside the United States go back of the Iron Curtain. As an illustration of Russian activity in studying world literature, Dr. Carleton brought back a booklet from Moscow, which is a Russian translation published in 1932 of 11 articles which had appeared in AGRICULTURAL ENGINEERING in 1927 and 1928.

More should be done to arrange for adequate translation of world literature for American agricultural engineers. If Americans are to have a leading role in world agricultural engineering, American agricultural engineering students should plan to become proficient in at least one other language.

A Challenge for the Future

Now an engineering challenge for the future — a challenge to have the courage of our convictions. In applying engineering to agriculture, let us believe that any agricultural-engineering development which society really needs can be accomplished. If this is not literally true, it is more nearly true than we have usually had the courage to imagine.

For a specific challenge, someone with the necessary soil and water engineering know-how should write a book on what could be done in the way of remaking the land and redistributing the water of the USA and the USSR, if their respective defense budgets were available for so worthy a cause. Don't misunderstand me. I am not suggesting that, under the circumstances, our defense budget is too large, but it is most intriguing to speculate on what could be done to supply water, food, and comfortable living space for our rapidly increasing population if resources of this magnitude were available. Also, our defense budget proves that we can do some astounding things if we believe the need is really urgent.

We are talking now about 40 billion dollars annually. A billion is a thousand million. What could be done with remaking the land — grading, leveling, draining, etc., with 40,000 million dollars? We now farm, actually till, about 400 million acres. Forty billion dollars would be an average of $100 an acre to improve the land we now till, or if you prefer, it would supply $500 an acre to improve 80 million acres of marginal land and thus add 20 percent to the area of tillable land.

What could be done to conserve and redistribute our total supply of fresh water with a budget of 40 billion — terraces, dams, canals, pumping stations? At the ASAE Florida Section meeting last April we were shown a drainage pumping station of which they were justly proud. This station handles the rainfall from 150 thousand acres. It has six pumps. Each pump is 10 feet in diameter and the combined capacity

(Continued on page 414)

TWIN DISC
Condensed Specifications
TWIN DISC FRICTION and FLUID DRIVES
BULLETIN No. 314
Small Mechanical Clutches
Medium & Large Mechanical Clutches
Wet-Type Clutches
Air-Actuated Clutches
Power Take-Offs
Reduction Gears
Fluid Couplings
Single-Stage Torque Converters
Three-Stage Torque Converters
Marine Gears
Get UNBIASED answers to your power transmission problems
TWIN DISC CLUTCH COMPANY · Main Office and Factory, RACINE, WISCONSIN, U.S.A.
HYDRAULIC DIVISION and EXPORT OFFICE ROCKFORD, ILLINOIS, U.S.A.
Branch Offices: Cleveland, Dallas, Los Angeles, Newark, New Orleans

Send for this *NEW* Twin Disc engineering guide

You'll find up-to-date specifications on every drive in the Twin Disc line in Bulletin 314—a brand-new 20-page brochure packed with technical data on construction details, dimensions, capacities and application recommendations. If you're engaged in designing new equipment drive lines, you'll want to keep Bulletin 314 handy as an accurate reference guide to the proper type and size of power transmission unit for any application.

Since 1918, Twin Disc industrial drives have earned a world-wide reputation for sound design and quality construction. And the Twin Disc line is *complete*. It includes mechanical, air, oil and electrically actuated friction clutches, fluid couplings, friction and fluid PTO's, single-stage and three-stage torque converters and marine gears. The fact that Twin Disc makes so many different types of drives is worth remembering. It means that Twin Disc engineers can offer *completely unbiased recommendations* whenever there's a question of drive selection.

Put Twin Disc engineering data at your fingertips . . . get your copy of Bulletin 314 *now*. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin. Hydraulic Division, Rockford, Illinois.

Mail This Coupon Today

TWIN DISC CLUTCH COMPANY
Racine, Wisconsin

Please send me a copy of your new Bulletin No. 314 covering specifications on all Twin Disc Friction and Fluid Drives.

Name_____

Title_____

Company_____

Street_____

City_____ State_____

Foundry Engineering aids product development!

This steel casting is another example of Unitcast's ability to cope with unusual problems. As the main body of a new-type Pulsation Dampener for The National Supply Company's oil field equipment, this casting had many tough end-use requirements. Basically, the part had to absorb shock, withstand corrosion, and hold hydrostatic test pressures up to 8,000 psi. The fewer the components in the part, the better the durability.

The ideal solution, a one-piece steel casting, required accurate suspension of a huge core on a minimum number of points to produce a horizontal "tank" within consistent tolerances. One subsequent finishing problem involved economically "sealing" the core suspension holes by a method that would hold up in end use—*plus* pass radiographic inspection!

Once again, Unitcast foundry engineering has helped a customer develop a new product for their well-known line. Why not call in Unitcast engineers on your product-development problems? Write today!

UNITCAST CORPORATION, Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

. . . Engineering in Agriculture

(Continued from page 412)

of the six pumps is over 2 million gallons a minute. This station cost about 2.5 million, a lot of money, but 40 billion would build 16 thousand such stations, more than three hundred for each state including Alaska and Hawaii.

This would of course be more drainage stations than we will need. What about some canals to redistribute the available water? I say "available" water because I will later mention briefly the matter of increasing the supply of fresh water. It costs about a half million dollars a mile to build a four-lane, divided, limited-access highway across reasonably level open country. Surely a good agricultural engineer experienced in water transportation and distribution could construct a very good high-capacity canal for a million dollars a mile, one that would be covered in some way to avoid water loss by evaporation. How many miles of such a canal for 40 billion? Forty thousand! This would reach across the United States more than ten times.

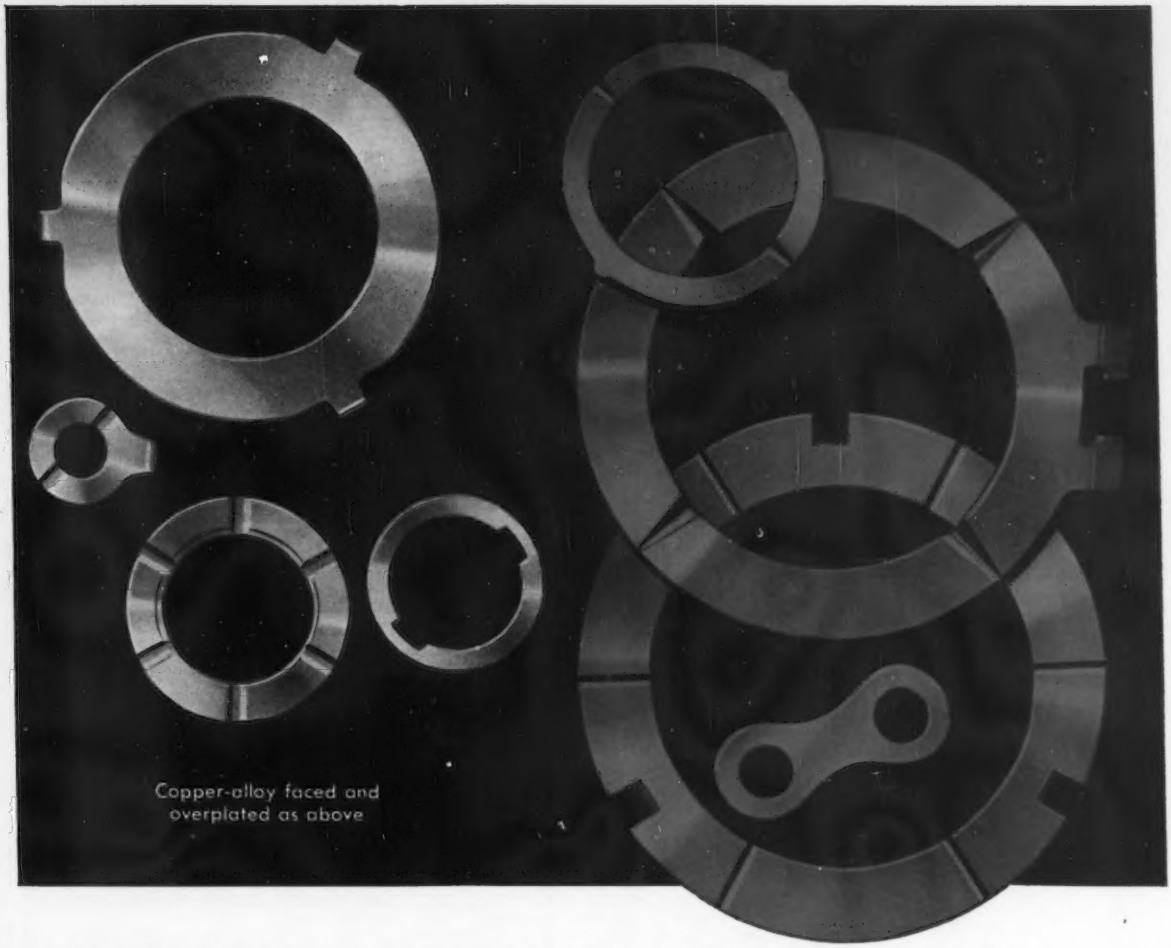
If such resources were available, consideration might well be given to increasing the supply of fresh water to meet the rapidly increasing water needs of our growing agriculture, expanding industry and multiplying homes. In 1958, the Congress authorized the Interior Department to work out plans for five plants to desalt sea water. It was estimated that these desalting plants would cost 1.5 million each and produce 1 million gallons of fresh water per day. How many such plants would one year's defense budget, 40 billion dollars, build? Twenty thousand, even if they cost 2 million dollars each. This would be enough to average one every quarter mile for 5,000 miles of coast line. At a million gallons a day each, the total production would be 20 billion gallons a day, nearly a fifth of our present average daily use of irrigation water, or enough for 100 gallons a day each for a population of 200 million.

Engineering Citizenship

Finally, a challenge to sincere, dedicated citizenship. A society based on a mechanized agriculture has some points of vulnerability. As the mechanization becomes more complete these points of vulnerability are accentuated.

Specialization and exchange are among the most significant characteristics of such an agriculture. Thus it is absolutely dependent on efficient transportation, adequate and honest processing industries, effective and reliable merchandizing organizations, a sound money program and last, but not least, a stable and equitable government. If any of these elements fail, all will be in serious trouble. If such trouble should occur, the basic cause will be a social rather than a technical failure.

Engineering has the continuing task of providing the physicial basis for progress, but the final answer depends on effective sociology. It is the duty and privilege of every agricultural engineer to accept the responsibilities of citizenship; to do his part in developing and maintaining a society which will enable the average citizen to reap the maximum benefits attainable from the almost limitless possibilities of physical and biological technology.



PRECISION THRUST WASHERS

Variety in design and material
Uniformity in quality and performance

In solid bronze, or steel faced with lead or tin-base babbitt, or sintered copper-alloy or bronze on one or both faces. They are cold rolled for heavy-duty operation. Flat, spherical or special shapes, with coined oil grooves, ball indentations on one or both sides, holes, nibs, lugs or scallops. Up to 5″ O.D. Extensive manufacturing facilities. Quality control. Complete engineering service.

FREE!

New Thrust Washer Design Guide

Just off the press! A helpful design guide, compiled by our engineering department. Write for your free copy—today!

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11081 SHOEMAKER, DETROIT 13, MICHIGAN

Copper-Alloy Lined Bearings

Spacer Tubes

Camshaft Bearings

Aluminum or Babbitt Lined Bearings

FEDERAL Mogul
SINCE 1899

Following are brief reviews of papers presented at ASAE meetings or other agricultural engineering papers of which complete copies are available. ASAE members may obtain copies of these papers without charge by returning order forms supplied upon payment of membership dues. Nonmembers, and members requesting more than 10 copies, may purchase papers at 50 cents each to cover carrying charges from the American Society of Agricultural Engineers, St. Joseph, Mich.

The Effect of Moisture on Weight-Volume Relationships of Small Grain, by Robert T. Lorenzen, assistant agricultural engineer, Colorado State University, Fort Collins, Colorado. Paper presented at the Annual Meeting of ASAE at Santa Barbara, California, June 1958, on a program arranged for a joint session of the Farm Structures and Electrical Power and Processing Divisions. Paper No. **58-111.**

In this paper the physical aspects of the two marketing units (bushel and hundredweight) are presented so that their relative merits can be compared. Special emphasis is made regarding the effect of moisture variation on these marketing units and physical factors affecting official grain grading standards are studied. Grains which were used in this research are wheat, corn, barley, rice and milo. Tests were also made on sawdust which has properties similar to ground grain.

Some Considerations in Grounding and Lightning Protection of Secondary Services and Related Equipment, by Marlin Harris, electrification advisor, Central Alabama Electric Cooperative. Paper presented at the Alabama Section Meeting of the ASAE, April 1958. Paper No. **58-343.**

The author discusses the fundamentals of grounding secondary services and related electrical equipment or appliances likely to be used in rural homes and farmsteads. He states that poor grounds or grounds of high resistance, though indirectly perhaps, can adversely affect the promotion of electrical equipment and appliances. With grounded secondary services of low resistance, he believes, a greater degree of safety and satisfaction can be derived from the use of electrical energy by consumers, which can be reflected in even greater use of it by them.

The Need of Precision Agricultural Equipment for the Canning Industry, by C. H. Mahoney, director, Raw Products Research Bureau, National Canners Association, Washington, D. C. Paper presented at the Annual Meeting of ASAE at Cornell University, Ithaca, N.Y., June 1959, on a program arranged jointly by the Power and Machinery Division and the National Joint Committee on Fertilizer Application. Paper No. **59-123.**

The production of vegetables and fruits for processing has become a highly specialized business operation, and in this paper the author points out that we must consider precision equipment for all phases of growing, harvesting and handling crops if we are to obtain the cumulative value of each of these operations and at the same time improve quality control of the raw product. This paper outlines agronomic specifications with respect to the type of equipment needed for precision planting and fertilizer application. The development of mechanical harvesters for vegetables and fruits is reviewed to point out evolutionary changes occurring in the production of these crops, the author states. In addition to changes in harvesting methods, the paper describes recent advances in the mechanization of bulk handling and storage of vegetables and fruits for processing. Also included in this paper, are illustrations of developments in harvesting, handling, loading and storage of fruits and vegetables and in precision planters which also incorporate precise fertilizer placement.

The Effect of Glass Fiber Covering on Silting and Rate of Discharge from Tile Drains, by Virgil Overholt, consultant, Hancock Brick and Tile Co., Findlay, Ohio. Paper presented at the Annual Meeting of ASAE at Cornell University, Ithaca, N. Y., June 1959, on a program arranged jointly by the Soil and Water Division and the Public Lands and Public Works group. Paper No. **59-200.**

Tests and experiments to combat the silting of tile drains in fine sandy soils are presented by the author in this paper. Included are explanations of the Rate of Silting — the average of three tests running for 88 days which showed the silt accumulation in the bare tile to be 3.49 times greater than in the filter protected tile; the Rate of Water Discharge — the rate of discharge from the fiber glass protected lines was 1.70 times greater than from the bare tile lines, the average of the first three tests, having 75% of the joint space protected; the Silt Accumulation per Cubic Foot of Water Discharged—each cubic foot of water entering the bare tile lines contained seven times more silt than a cubic foot of water from the fiber protected lines, the average of the first three tests. Also presented is the test in which the filter was completely wrapped around the tile in one plot. The other plot had bare joints. In this test the filter gave almost complete protection against silting. The discharge from the filter equipped plot was 2.26 times greater than from the bare tile plot.

Demand Studies on Electric House Heating, Air Conditioners, and Crop Driers, by L. B. Altman and L. F. Charity, respectively, agricultural engineer, Farm Electrification Research Branch, AERD, ARS, USDA, and associate professor, Agricultural Engineering Dept., Iowa State College, Ames. Paper presented at the Annual Meeting of ASAE at Cornell University, Ithaca, N. Y., June 1959, on a program arranged by the Electric Power and Processing Division. Paper No. **59-301.**

This manuscript deals with a study made of the effects of three appliances on the annual load factors of rural electric distribution systems in Iowa. The author states that electric house heating lowered annual load factors unless off-peak controls were used, and that heating systems with off-peak controls and single-stage thermostats reduced demand at the time of the distribution system peak to a greater extent than those with two-stage thermostats. Also pointed out is the fact that although there was no diversity in time of operation of air conditioners and little diversity in time of operation of crop driers, these loads improved annual load factors. The paper also reveals that the operation of window air conditioners was such that motors did not cycle on the thermostats and that crop driers required a large transformer for an operation that frequently involved only a few days per year.

Problems in Collecting and Processing Livestock Manures, by S. A. Hart, associate agricultural engineer, University of California, Davis. Paper presented at the Annual Meeting of ASAE at Cornell University, Ithaca, N. Y., June 1959, on a program arranged by the Farm Structures Division. Paper No. **59-405.**

According to the author, manure management on livestock farms today is primarily necessary for fly control, although aesthetics and animal health aspects of sanitation are important factors. He also states that livestock manures are a favorite breeding media for flies, that the proper management of this manure is necessary to break the fly life cycle, and that frequent cleanup of the manure and subsequent proper handling is an assured way of controlling fly production. The paper discusses the principles of materials handling applicable to the problems of manure management. The operations of harvesting, storing, processing, and disposal are discussed. Findings from the research on this at the University of California are described.

It is pointed out that manures may or may not be a profit part of the livestock enterprise, but adequate handling of the manure is a necessity. Methods to minimize cost and possibly give a profit are considered, while at the same time achieving the primary goals of adequate sanitation and fly control.

Prescribed Burning as a Tool of Forest Management in New Jersey, by G. T. Bamford, principal forester, Department of Conservation and Economic Development, Trenton, N. J. Paper presented at the Annual Meeting of ASAE at Cornell University, Ithaca, N. Y., June 1959, on a program arranged by the Public Lands and Public Works group. Paper No. **59-504.**

This paper presents the foresters' recommendation of prescribed burning as a dual-purpose tool to: (1) Increase the productivity of the woodland by creating conditions more favorable to the establishment and maintenance of pine rather than hardwood species; and (2) reduce the damage caused by wildfires by a gradual reduction of the accumulated flash fuels on the ground, so that in the event of a wildfire the killing intensity is lessened and suppression more easily accomplished. The author states that for eleven years prescribed burning has been practiced in the oak-pine type forest, and that experience has shown that the controlled use of light winter fires can be made at an average cost of 50 cents per acre. He also states that research has provided data to show that prescribed burning has no appreciable effect on the highly acid, droughty soils of the pine region, and that changes in composition, age and character of vegetation has favorably increased deer browse. Pointed out also, is the fact that the relationship between prescribed burning and water is currently being studied.

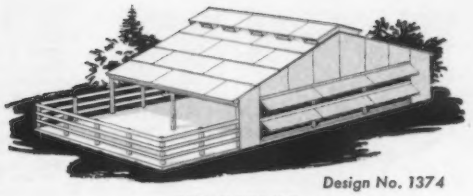
TO Meet Today's FARM BUILDING NEEDS LOOK TO WEYERHAEUSER 4-SQUARE

● Buildings are an important capital investment on every farm. They are also valuable tools in helping to increase farm incomes.

As capital investment, buildings should be economically constructed. As working tools, buildings should be designed to serve many uses. They must be planned to save chore time and increase production . . . while being versatile for use in a variety of operations.

Weyerhaeuser 4-Square Lumber fills the need for an economical building material that gives long life and low up-keep cost. Weyerhaeuser 4-Square Farm Building Plans assure practical, functional use . . . buildings designed to help increase farm income.

You will be interested in seeing your Weyerhaeuser 4-Square Lumber Dealer and acquainting yourself with the wide assortment of lumber items and new special products now available.



Design No. 1374

PIG PARLOR

Here is the answer to year-round hog production. Concrete floor aids sanitation. Side walls can be opened for ventilation or closed for protection from weather.

Design No. 3213

ARCHED ROOF UTILITY BUILDING

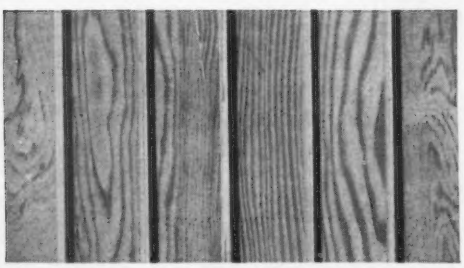
Floor plans are available showing how this practical, versatile building can be used as a dairy barn, machinery shed, cattle shelter, or poultry house.

These plans, and scores more, are available from your local Weyerhaeuser 4-Square Lumber Dealer.

Weyerhaeuser 4-SQUARE®

LUMBER AND BUILDING PRODUCTS

BOARDS AND BATTENS give a snug, economical exterior for many types of farm buildings.



VERTICAL DROP SIDING pattern 116 is another practical, easy-to-apply covering for exterior walls.

Basically Better Because...

Trademarked Weyerhaeuser 4-Square Lumber is:

- **PROPERLY SEASONED**—scientific kiln-drying increases strength and dimensional stability. Kiln-dried lumber also finishes easily and holds nails securely.
- **ECONOMICAL TO USE**—because this lumber is cut to exact lengths with smooth, square ends. This saves labor, and reduces material waste.
- **CORRECTLY GRADED AND IDENTIFIED**—so that each piece meets the strength and other quality requirements of its grade. You know exactly what you are buying.
- **AVAILABLE IN A BROAD LINE OF PRODUCTS**—for all building needs. Your Weyerhaeuser 4-Square Lumber Dealer can supply you with the correct grades and species for every farm job, such as sheathing, framing, siding and finish.

See your Weyerhaeuser 4-Square Lumber Dealer or write us for illustrated farm building books. State the type of buildings or equipment items in which you are interested—Hog, Cattle, Poultry, Sheep, Crop Storage, Machinery Sheds, or Modern Farm Homes.

WEYERHAEUSER SALES COMPANY

2557 First National Bank Building • St. Paul 1, Minnesota

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Brown, Arlen D.—Assoc. prof. of agr. mechanics, agr. eng. dept., Purdue University, Agr. Eng. Bldg., Lafayette, Ind.

Burke, Richard J.—Staff engr., Standard Fruit Co. (Mail) 1626 Napoleon Ave., New Orleans 15, La.

Buzenberg, Robert J.—Pres. and gen. mgr., Viking Mfg. Co., Box 342, Manhattan, Kans.

Coleman, R. N.—Chief product dev. engr., International Harvester Co., 7 So. 600 County Line Rd., Hinsdale, Ill.

Constantinoff, Andrew — Dept. head, Design Bureau for Farm Machinery. (Mail) Apt. 7, N 24 Lenin St., Riga, Latvian, USSR

Coover, Francis H.—Agr. sales engr., Southern California Edison Co. (Mail) P.O. Box 351, Los Angeles 53, Calif.

Foley, John R.—Ext. agr. engr., agr. eng. dept., Purdue University, Lafayette, Ind.

Hicks, William L. — Pres., Led Ballast Inc. (Mail) Box 265, 2655 Pearl St., Boulder, Colo.

Jacobs, Paul—Sr. engr., John Deere Tractor Res. and Eng. Center, Blackhawk Rd., Waterloo, Iowa

Kayal, Ajit K.—Graduate student. (Mail) 21 S. Randall Ave., Madison 5, Wis.

Kumra, Om P.—Asst. dir. of designing, Central Water and Power Commission, Government of India. (Mail) 2 Mahadev Rd., New Delhi, India

Larson, Marvin E. — Asst. prof. of mechanized agr., agr. eng. dept., South Dakota State College, Brookings, S.D.

McMillan, Donald C.—Zone sales mgr., Detroit Diesel Engine Div., General Motors Corp. (Mail) 22 W534 Tamarack Dr., Glen Ellyn, Ill.

Meulenbergh, Francis X.—Sales mgr., W. Hertecant Plough Works. (Mail) 173 Avenue Adolphe Buyl, Brussels, Belgium

Potter, John D.—Commercial and agr. engr., Gulf Power Co., Defuniak Springs, Fla.

Potter, Richard A.—Agr. and commercial sales rep., Gulf Power Co., 75 N. Pace Blvd., Pensacola, Fla.

Thompson, Kenneth F.—Product mgr., materials handling equipment, New Holland Machine Co., Div. of Sperry Rand Corp., New Holland, Pa.

Tomalin, Paul G.—Gen. mgr., Marine Products Div., National-U.S. Radiator Corp., Box 231, Middletown, Pa.

van Heerden, Willem M.—Engr., agr. tech. services dept., Soil Conservation and Ext. Div., Hofmeyr, Cape, Union of South Africa

Vincent, Hugh C., Jr.—Salesman, Lilliston Implement Co. (Mail) 384 Franklin Dr., Murfreesboro, N. C.

Wadleigh, Ralph S.—Hydraulic engr., (SCS) USDA. (Mail) High St., Jefferson, Mass.

Wheeldon, Paul M. — Draftsman, agr. eng. dept., South Dakota State College, Brookings, S. D.

White, Gene R.—Sales and service trainee, John Deere Intercontinental-S.A., Moline, Ill.

TRANSFER OF MEMBERSHIP

Bowman, George M.—Engr., Lockwood Graders of North Dakota, Inc. (Mail) 1111 Park Dr., Grand Forks, N.D. (Associate Member to Member)

Milne, Charles M.—Asst. agr. engr., Maine Agr. Exp. Sta., agr. eng. dept., University of Maine, Orono, Maine (Associate Member to Member)

Sides, Samuel E.—Asst. agr. engr., Maine Agr. Exp. Sta., Maine Potato Handling Res. Center, P.O. Box 532, Presque Isle, Maine (Associate Member to Member)

STUDENT MEMBER TRANSFERS

Abdelwadoud, Abdalla A.—(University of California). (Mail) 521 Russell Blvd., Davis, Calif.

Anderson, Dallas N.—(Oklahoma State University). (Mail) Martha, Okla.

Anderson, Donald C.—(Kansas State College). (Mail) Enterprise, Kans.

Anderson, Gordon L.—(North Dakota Agricultural College). (Mail) Harwood, N. D.

Appel, Richard D.—(State College of Washington). (Mail) Endicott, Wash.

Armacost, Lawrence V.—(University of Idaho). (Mail) 508 N. Jefferson #7, Moscow, Idaho

Bacus, Oliver B.—(University of Idaho). (Mail) Apt. 6E, North Main Village, Moscow, Idaho

Banes, Charles R. — (Mississippi State University). (Mail) R.R. 3, Box 39-A, Canton, Miss.

Basrur, Krishna K.—(Ontario Agricultural College, Canada). (Mail) No. 31, Citizen Co-op. Housing Society, 206, Cadeli Rd., Mahim 16, Bombay, India

Beard, Ray D.—(Iowa State College). (Mail) Grandview, Iowa

Beckwith, Mervin D.—(Michigan State University). (Mail) 2780 E. Grand River, East Lansing, Mich.

Bellinger, Page L. — (Michigan State University). (Mail) 1303-G University Village, East Lansing, Mich.

Bennett, Richard T.—(University of Illinois). (Mail) Eng. dept., International Harvester Co., 7 So. 600 County Line Rd., Hinsdale, Ill.

Bentz, Duane R.—Box 207, Stockbridge Hall, North Dakota Agricultural College, Fargo, N. D.

Berlage, Arnold G. — (Oregon State College). (Mail) 311 Bayliss Ave., Rockford, Ill.

Berney, James E. — (Oregon State College). (Mail) 437 N. 16th St., Corvallis, Ore.

Bernhardt, Richard P. — (Iowa State College). (Mail) Odebolt, Iowa

Bieker, Hilary J.—(University of Idaho). (Mail) 3-A W. Sixth Village, Moscow, Idaho

Black, David A.—(Oregon State College). (Mail) Star Route, Etna, Calif.

Brennan, John J. — (University of Illinois). (Mail) 604 E. Armory, Champaign, Ill.

Britton, Jerry A. — (Oregon State College). (Mail) 909 E. 8th St., The Dalles, Ore.

Brossart, Raymond J.—(Colorado State University). (Mail) U.S. Bur. of Land Management, New Custom House Bldg., Denver, Colo.

Brown, Andrew M. — (North Dakota Agricultural College). (Mail) 1118 32nd Ave., Greeley, Colo.

Brown, Donnell W. — (Oklahoma State University). (Mail) 1015 W. Fifth St., Stillwater, Okla.

Burns, Dennie G. — (Oregon State College). (Mail) R.R. 1, Box 241, Hermiston, Ore.

Carpenter, Jerry D.—(University of Missouri). (Mail) 11 Cliff Dr., Columbia, Mo.

Cass, Joseph E.—(University of Idaho). (Mail) Apt. 6B, North Main Village, Moscow, Idaho

(Continued on page 420)

ROCKFORD

Small Spring Loaded

Heavy Duty Spring Loaded

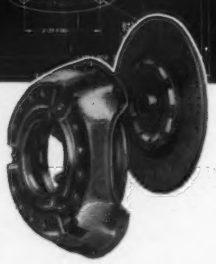
Oil or Dry Multiple Disc

Heavy Duty Over Center

Power Take-Offs

Speed Reducers

Design and Stay With the Genuine



ROCKFORD CLUTCHES provide the advantages of heat-treated, hardened and ground steels—flat, non-grab facings—heat dissipation—dirt exclusion—and fine adjustments. Only ROCKFORD provides clutch levers that reduce friction, improve release action and prevent lever throw-out. These wear-resisting, life-lengthening clutch features are essential to designs that must be projected with a thought to uses of tomorrow. ROCKFORD engineers now are working with many companies on their future designs—to provide custom-engineered clutches for long range economy. Their services are available to you.

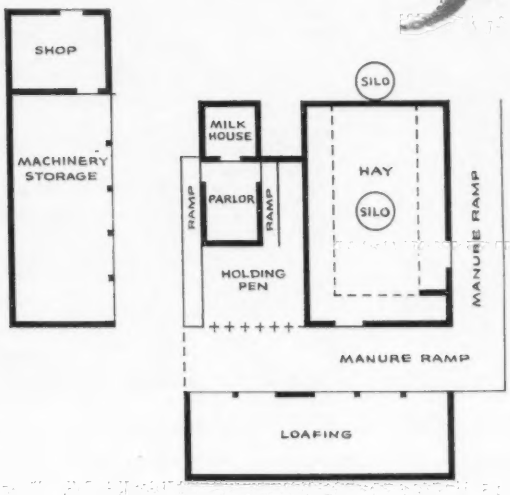
SEND FOR THIS HANDY BULLETIN
Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

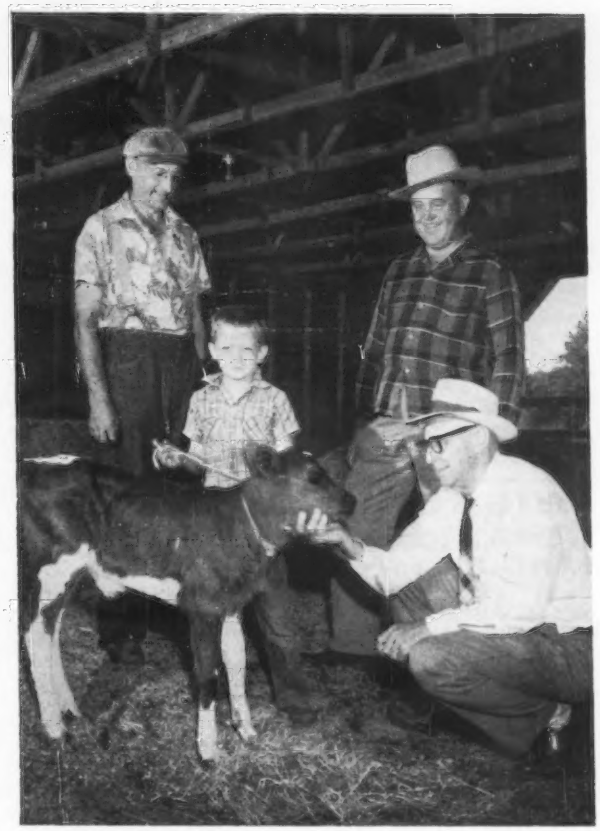
ROCKFORD Clutch Division BORG-WARNER
1325 Eighteenth Ave., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

EXAMPLE: Morris Dagnen of Montesano, Washington formerly milked 25 cows in a stanchion-type barn that was cramped and inefficient. With young Scotty Dagnen growing to be a dairyman, he decided more volume was required. He called on Heston Weyrich, (center) County Agent, and H. E. Wichers, (right) Agricultural Extension Specialist, for planning help. Silos were retained, and the old barn was remodeled for feeding and hay storage. New structures were located as shown. Now 50-65 cows are handled without any increase in his working time.

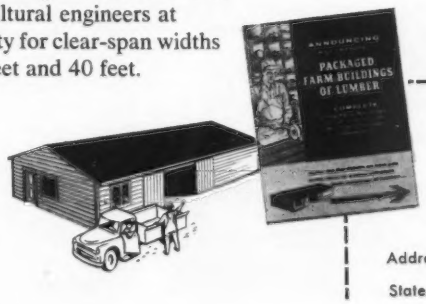
How would you advise him?





YOU are the specialist farmers look to for advice in farmstead organization. Take advantage of the help you can get from *Your Local Lumber Dealer*. Get acquainted with him. His knowledge of building or remodeling procedures, and the technical material available from manufacturers through him, will prove very useful.

SEND FOR FREE BUILDING INSTRUCTIONS—With these complete directions, even the most inexperienced farmers and rural builders can erect well built general purpose farm buildings. These structures were designed by agricultural engineers at Michigan State University for clear-span widths of 24 feet, 30 feet, 36 feet and 40 feet.



Use convenient coupon or write to West Coast Lumbermen's Association, 1410 S. W. Morrison Street, Portland 5, Oregon.

WEST COAST LUMBER

Douglas Fir • West Coast Hemlock
Sitka Spruce • Western Red Cedar

WEST COAST LUMBERMEN'S ASSOCIATION
1410 S. W. Morrison, Portland 5, Oregon

Please send me your free Utility Farm Building Construction Sheets for the following widths:

☐ 24 ft. ☐ 30 ft. ☐ 36 ft. ☐ 40 ft.

Name_____

Address_____

State_____

. . . Applicants

(Continued from page 418)

Chilton, Charles B.—Box 3247, Virginia Polytechnic Institute, Blacksburg, Va.

Clark, William R., Jr.—(University of California). (Mail) 1124 F St., Davis, Calif.

Clarke, Robert L. — (Oregon State College). (Mail) P.O. Box 463, Rainier, Ore.

Coate, Lester E. — (Oregon State College). (Mail) 9332 E. Chapman, Garden Grove, Calif.

Cuerington, Aaron M. — Stadium Dorm, Ohio State University, Columbus 10, Ohio

Cullen, Richard B.—(South Dakota State College). (Mail) 111 W. Eighth St., Brookings, S. D.

Davis, Donald—(North Carolina State College). (Mail) R.R. 1, Box 105, High Point, N. C

Davis, Roger L.—(South Dakota State College). (Mail) 524 Third St., Brookings, S. D.

DeJong, Nico H.—(Purdue University). (Mail) 175 Littleton, Apt. 1A, West Lafayette, Ind.

Denniston, Wayne E.—(Michigan State University). (Mail) 305-D Hickory Lane, East Lansing, Mich.

DePriester, Jack—(Michigan State University). (Mail) R.R. 1, Box 139, Hickory Corners, Mich.

Doig, Jay C.—(Montana State College). (Mail) White Sulphur Springs, Mont.

Donelson, Keith M.—(Kansas State College). (Mail) c/o Ralph T. Donelson, RFD, Strong City, Kans.

Dorgan, Charles — (Kansas State College). (Mail) Cullison, Kans.

Douglas, Richard L. — (Purdue University). (Mail) R.R. 7, Crawfordsville, Ind.

Drews, David H.—(University of Nebraska). (Mail) 2700 N. 27th St., Lincoln, Nebr.

Durscher, Harold E. — (Iowa State College). (Mail) R.R. 3, Elgin, Iowa

Edgar, Carl L. — (University of Missouri). (Mail) 1501 Rosemary, Columbia, Mo.

Edwards, Jerry P.—(Oklahoma State University). (Mail) Box 355, Alva, Okla.

Ellsworth, Robert B. — (University of Idaho). (Mail) Jackson, Wyo.

Ewalt, Dale J.—(Michigan State University). (Mail) Box 353, R.R. 1, Berrien Springs, Mich.

Ewalt, Dean C. — (Michigan State University). (Mail) Barber-Greene Co., 400 N. Highland Ave., Aurora, Ill.

Fairless, Robert—(Oklahoma State University). (Mail) R.R. 1, Stuart, Okla.

Faulkner, Macon D.—(Louisiana State University). (Mail) Rice Exp. Station, Crowley, La.

Fickle, J. Clark—(Purdue University). (Mail) R.R. 6, Frankfort, Ind.

Findlay, Jack B.—(Iowa State College). (Mail) R.R. 3, Harlan, Iowa

Finney, Essex E.—Box 3622, Virginia Polytechnic Institute, Blacksburg, Va.

Fitzsimmons, Delbert W.—(University of Idaho). (Mail) 508 N. Jefferson, #3, Moscow, Idaho

Foerster, Eugene P. — (A. & M. College of Texas). (Mail) Ralston Purina Co., Battle Creek, Mich.

Folsche, William R. — (Kansas State College). (Mail) (SCS) USDA, Belleville, Kans.

Frasier, Gary W.—(Colorado State University). (Mail) Southwest Water Conservation Lab., ARS, Phoenix, Ariz.

Frederick, Hugh L.—(Alabama Polytechnic Institute). (Mail) R.R. 4, Winfield, Ala.

Fritz, David P. — (University of Nebraska). (Mail) 2815 Washington, Apt. 3, Lincoln, Nebr.

Gearig, Deane M. — (Michigan State University). (Mail) R.R. 1, Alma, Mich.

Gee, Ralph K.—(University of Illinois). (Mail) 1708 W. Church St., Champaign, Ill.

Gerdes, Marvin L. — (University of Illinois). (Mail) 1116 W. California, Urbana, Ill.

Gilson, Leonard L. — (Oregon State College). (Mail) Scappoose Soil Conservation Dist., St. Helens, Ore.

Glanville, Carroll G.—(Kansas State College). (Mail) Paola, Kans.

Goel, Pirthi C.—(Indian Institute of Technology). (Mail) c/o Messrs. Banwari Lal Ram Kumar, P.O. Uklana Mandi, Dist. Hissar, (Punjab) India

Goetsch, Lyman L. — (Kansas State College). (Mail) Brewster, Kans.

Griffith, Donald — (University of Wisconsin). (Mail) 1443 N. 25th St., Grand Junction, Colo.

Gulati, Om P. — (Indian Institute of Technology). (Mail) B-2, 605, Meena Bazar, Ludhiana (Punjab) India

Gunter, Billy J.—(A. & M. College of Texas). (Mail) SCS, USDA, Dumas, Texas

Gutekunst, Larry W.—(University of Missouri). (Mail) 8 Watson Place, Columbia, Mo.

Hankins, Carrol F.—(University of Arkansas). (Mail) R.R. 2, Box 460, Pine Bluff, Ark.

Hansen, James C.—(State College of Washington). (Mail) 52-A N. Fairway, Pullman, Wash.

Hansen, Leslie A.—(Iowa State College). (Mail) Turin, Iowa

Hawk, Dale R.—(Kansas State College). (Mail) Carlyle, Kans.

Heidlage, Robert — (Oklahoma State University). (Mail) 719 Colorado Ave., Chickasha, Okla.

Henry, John T.—(Alabama Polytechnic Institute). (Mail) Marion Junction, Ala.

Herndon, Charles S.—(University of Arkansas). (Mail) 351 Razorback Rd., R.R. 2, Fayetteville, Ark.

Hicks, Richard C.—(University of Missouri). (Mail) 905 W. Broadway, Columbia, Mo.

Hitch, Donald W.—(Purdue University). (Mail) R.R. 1, Lizton, Ind.

Hodel, Glen W.—(Purdue University). (Mail) Garden Grove, Inc., 11th Ave., Union Grove, Wis.

Hoffer, Garold K. — (Michigan State University). (Mail) 6094 E. Cleveland Rd., Ashley, Mich.

Holdren, Richard D.—(Ohio State University). (Mail) 1979 Iuka Ave., Columbus 1, Ohio

Hood, Clarence E., Jr.—(North Carolina State College). (Mail) 30 W. Fourth St., Newton, N. C.

Horton, James A. — (North Carolina State College). (Mail) Academy St., Ahoskie, N. C.

Ingram, Raymond L. — (Louisiana Polytechnic Institute). (Mail) R.R. 1, Box 104-A, Tillar, Ark.

Isaacson, Raymond D. — (University of Nebraska). (Mail) 1542 "O" St., Apt. 12, Lincoln, Nebr.

Isbell, Perry T. — Agr. Eng. Bldg., Louisiana State University, Baton Rouge, La.

Jackson, Gary L.—(Purdue University). (Mail) 1807 N. 16th St., Lafayette, Ind.

Johnson, Vernon L.—(University of Minnesota). (Mail) 7421 Lyndale Ave., S., Minneapolis 23, Minn.

Jones, Glen E. — (University of Arkansas). (Mail) R.R. 2, Box 240, Springdale, Ark.

Kegel, Arnold R.—(State College of Washington). (Mail) 605 Arbor, Pullman, Wash.

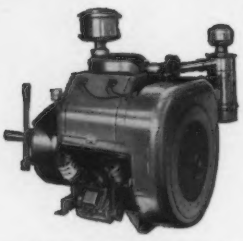
Klueter, Herschel H.—(University of Illinois). (Mail) 1013 W. John, Champaign, Ill.

Koepele, John C.—(Michigan State University). (Mail) R.R. 1, Grand Ledge, Mich.

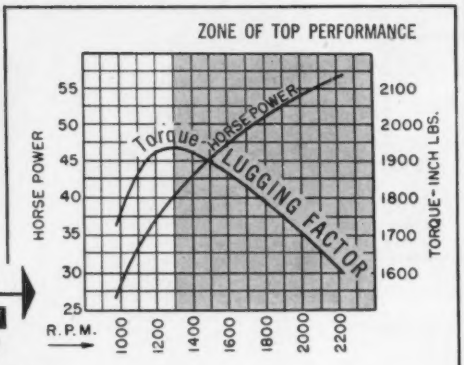
Kurtz, Herbert M.—(A. & M. College of Texas). (Mail) (SCS) USDA, Breckenridge, Texas

Judge your power unit by its

LUGGING FACTOR!



Model VR4D 56 hp



WISCONSIN
heavy duty Air-Cooled
ENGINE *power curve*

When the power load suddenly *builds up* and the engine speed *slows down* . . . how long will the engine *hang on* and carry the increased load without stalling?

The answer lies in the HIGH TORQUE LUGGING FACTOR which is an integral part of "Wisconsin" basic engineering. The point at which an engine will stall under suddenly increased loads is the *High Point* in the TORQUE CURVE. As a case in point, analyze the Wisconsin Model VR4D power curves reproduced here.

This engine develops its maximum horsepower (56 hp.) at 2200 rpm. at which point it registers a torque of 1600 inch-lbs. The engine runs into heavy going. The load builds up fast. The rpm. slows down to 2000, 1800, 1600 and 1400 rpm., reaching its maximum torque *at the low speed* of 1300 rpm.

In terms of power service to the user, this simply means that your Wisconsin Engine is designed *to provide dependable load-holding power at low engine speeds.* This, in turn, means fewer shutdowns, less wear and tear, more usable power and more versatile performance for your dollar investment.

These are reasons why it pays to specify "Wisconsin Power" for your equipment. For a briefing on the full line, write for Engine Bulletin S-237.

50 YEARS OF PROGRESSIVE ENGINEERING

WISCONSIN MOTOR CORPORATION Milwaukee 46, Wisconsin

World's largest builders of Heavy-Duty Air-Cooled Engines

. . . Applicants

Lazorenko, Peter—Churchill Hall, North Dakota Agricultural College, Fargo, N. D.

Love, Orval R.—(A. & M. College of Texas). (Mail) Ralston Purina Co., Box 86, Shelby Sta., Louisville 17, Ky.

Lovig, Glenn O., Jr. — (Iowa State College). (Mail) RFD, Gilman, Iowa

Lucas, Paul E.—(Purdue University). (Mail) R.R. 3, Knox, Ind.

McConnell, Lloyd L.—(Oregon State College). (Mail) P.O. Box 918, Wasco, Calif.

McDonald, Howard W. Jr.—(Louisiana Polytechnic Institute). (Mail) 3305 Alabama Ave., Shreveport, La.

McFall, Robert L. — (University of Idaho). (Mail) Manzanola, Colo.

McKinney, Jimmy G. — (Oklahoma State University). (Mail) Blanchard, Okla.

Madden, William L.—(Oregon State College). (Mail) 517 Foy, Modesto, Calif.

Mast, Robert E.—(Purdue University). (Mail) R.R. 5, Frankfort, Ind.

Meendering, Gerrit — (Iowa State College). (Mail) Box 138, Sheldon, Iowa

Morris, Robert J.—(Mississippi State University). (Mail) Box 136, Friars Point, Miss.

Morrison, Donald C.—(Oregon State College). (Mail) 2510 S. E. 51st, Portland 6, Ore.

Mundell, Lyle W.—(Iowa State College). (Mail) Chatfield, Minn.

Nearpass, Gregory M.—(Oregon State College). (Mail) Star Route, Coeur 'd 'Alene, Idaho

Nelson, Burnell E. — (Iowa State College). (Mail) R.R. 1, Galva, Iowa

Nelson, Leon F. — (University of Nebraska). (Mail) 1215 N. 33rd St., Lincoln, Nebr.

Nerdahl, Sidney D. — (North Dakota Agricultural College). (Mail) B-23 N. Court, Fargo, N. D.

Newman, Edsel N. — Room 5310, Selleck Quadrangle, University of Nebraska, Lincoln 3, Nebr.

Nolte, David F. — (University of Missouri). (Mail) 604 Conley, Columbia, Mo.

Oglesby, Joseph A., Jr. — (Mississippi State University). (Mail) Chatham, Miss.

Ohrenberg, Alvin J.—(University of Missouri). (Mail) 203 Beverly Apts., Columbia, Mo.

Oldfather, Raymond L. — (Iowa State College). (Mail) R.R. 1, Arlington, Iowa

Olthoff, James A.—(Purdue University). (Mail) 17308 South Park, South Holland, Ill.

Otto, Wayne E. — (Montana State College). (Mail) 1207 Cougar St., Bozeman, Mont.

Patrick, Harold L. — (University of Missouri). (Mail) R.R. 2, Campbell, Mo.

Pay, Joe W.—(University of Arkansas). (Mail) Des Arc, Ark.

Pepper, Vernon D. — (South Dakota State College). (Mail) 1319 "C" St., Brookings, S. D.

Pinkerton, John W. — (Iowa State College). (Mail) R.R. 2, Aledo, Ill.

Pixlee, William F. — (State College of Washington). (Mail) Box 682, Ephrata, Wash.

Prince, James R. — (Alabama Polytechnic Institute). (Mail) RFD, Roanoke, Ala.

Priode, Carl B.—Box 5272, Virginia Polytechnic Institute, Blacksburg, Va.

Provart, R. Wayne — (University of Illinois). (Mail) 1206½ N. Goodwin, Urbana, Ill.

Roane, Thomas M.—Box 5553, Virginia Polytechnic Institute, Blacksburg, Va.

Robertson, Keith E. — (Michigan State University). (Mail) 2756 E. Grand River, East Lansing, Mich.

Romig, Bernard E. — (Iowa State College). (Mail) R.R. 2, Villisca, Iowa

Ross, Elwin A. — (University of Idaho). (Mail) 132 W. Lauder St., Moscow, Idaho

Salomonson, Vincent V. — Agr. eng. dept., Colorado State University, Fort Collins, Colo.

Sasser, Preston E. — (North Carolina State College). (Mail) R.R. 2, Dover, N. C.

Saufferer, Warren B. — (University of Minnesota). (Mail) 2501 Lowry Ave., N.E., Minneapolis, Minn.

Saunders, Neil H. — (North Dakota Agricultural College). (Mail) D-12 North Court, Fargo, N. D.

Sayre, Dale E. — (Colorado State University). (Mail) Ralston Purina Co., Omaha, Nebr.

Scherer, LeRoy F. — (University of Idaho). (Mail) Homedale, Idaho

Shearin, Wilton F. — (University of Tennessee). (Mail) R.R. 1, Bolivar, Tenn.

Siebens, Daryl J. — Agr. eng. dept., South Dakota State College, Brookings, S. D.

Sigala, Cruz M. — Box 5529, Virginia Polytechnic Institute, Blacksburg, Va.

Simmons, Jesse A., Jr. — (Louisiana Polytechnic Institute). (Mail) 1001 Chautauqua St., Ruston, La.

Simons, C. Gene—(Purdue University). (Mail) 324 N. Independence, Apt. 4, Tipton, Ind.

Smelcer, Dale R. — (University of Idaho). (Mail) Box 417, Priest River, Idaho

Smith, Wayne O., Jr. — (A. & M. College of Texas). (Mail) R.R. 3, Lampasas, Texas

Sneed, Ronald E. — (North Carolina State College). (Mail) R. 3, Oxford, N. C.

Sparks, Roger C. — (University of Idaho). (Mail) P.O. Box 1365, Wallace, Idaho

Stallworth, Edward B. — (Alabama Polytechnic Institute). (Mail) Pine Apple, Ala.

Stone, Leslie E. — (State College of Washington). (Mail) R.R. 1, Newman Lake, Wash.

Strand, Daniel H. — (University of California). (Mail) 10 College Park, Davis, Calif.

Studer, Louis L. — (Kansas State College). (Mail) R.R. 2, Wathena, Kans.

Sund, Clifford D. — (North Dakota Agricultural College). (Mail) 1125 16th St., N., Fargo, N. D.

Sutphin, John W., Jr. — (Montana State College). (Mail) 712 S. Willson Ave., Bozeman, Mont.

Swayze, L. Duane — (Michigan State University). (Mail) 2756 E. Grand River, East Lansing, Mich.

Swift, George W. — (University of Illinois). (Mail) 1001 W. California, Urbana, Ill.

Teale, Robert E. — (Ohio State University). (Mail) 143 E. Blake Ave., Columbus 2, Ohio

Tiwari, Harish C. — Agr. eng. dept., Ontario Agricultural College, Guelph Ont., Can.

Trees, Alan V. — (Iowa State College). (Mail) R.R. 1, Belmond, Iowa

Waligorski, John A. — (University of Wisconsin). (Mail) 1511 Madison St., Madison 5, Wis.

Watson, Cecil A. — Agr. eng. dept., North Dakota Agricultural College, Fargo, N. D.

Wells, Grant D. — (Michigan State University). (Mail) 887 Hoxie Rd., North Adams, Mich.

Werbach, Donald K. — (Iowa State College). (Mail) Lone Tree, Iowa

Wetzel, Donald T. — (University of Missouri). (Mail) Couch, Mo.

Williams, Cecil E.—(A. & M. College of Texas). (Mail) 514 Catalpa St., Clarksdale, Miss.

Wilson, Howard M., Jr. — Box 6334, Virginia Polytechnic Institute, Blacksburg, Va.

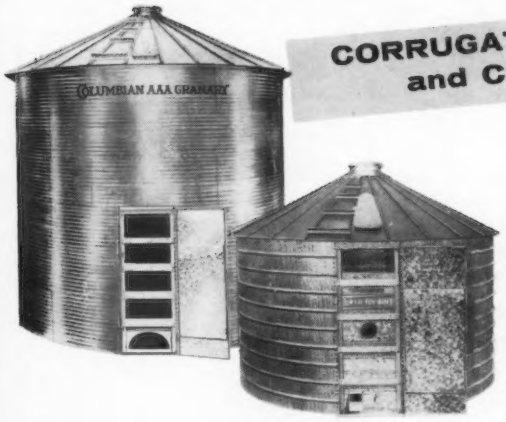
Windham, John W., Jr. — (Louisiana Polytechnic Institute). (Mail) R.R. 2, Box 52, Ruston, La.

Yee, Theodore W. Y. — (Oregon State College). (Mail) 3102 Kaohinani Ave., Honolulu, Hawaii

Zackrison, Herbert J.—(State College of Washington). (Mail) Woodinville, Wash.

DESIGNED FOR MAXIMUM EFFECTIVENESS

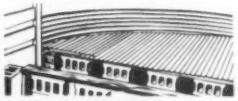
of Grain Conditioning . . . Fumigation . . . Storage



CORRUGATED STEEL GRAIN BINS and Conditioning Systems

MASTER-CRAFTED BY COLUMBIAN SINCE 1893

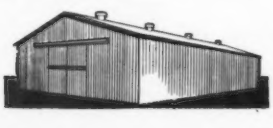
Columbian Red Top Grain Bins and AAA Granaries are *tight* — designed for maximum efficiency of grain storage and optimum effectiveness of fumigation and conditioning. Such features as factory assembled and sealed doors and door frames, modern sealing compounds for all seams and steel backed neoprene washers for all bolts add extra tightness to Columbian master-crafted bins. As a result, they offer a more effective resistance to the entry of moisture and increase the moisture-reducing efficiency of natural air conditioning on corn, milo, soybeans, rice and other grains.



• **Columbian Perforated Floor Conditioning Systems** are of flat or corrugated 16 gauge steel with 10.5% of their area perforated. This ratio has been found to be most effective for efficient aeration. Columbian duct systems are easy to install and effective in helping keep grain in condition. Columbian portable fan assemblies are available in a wide variety of sizes.

FOR FLAT GRAIN STORAGE

Columbian Rigid Frame Buildings are constructed with specially reinforced side and end walls. Trussless design permits full use of interior space.



WRITE for fully illustrated literature and specifications on Columbian Grain Bins and natural air conditioning systems. Also FREE Columbian Farm Equipment Catalog.

COLUMBIAN STEEL TANK COMPANY

P. O. Box 4013-W Kansas City, Mo.

We do contract steel fabrication

PERSONNEL SERVICE BULLETIN

Note: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated. "Agricultural Engineer" as used in these listings is not intended to imply any specific level of proficiency or registration as a professional engineer. Items published herein are summaries of mimeographed listings carried in the Personnel Service, copies of which will be furnished on request. To be listed in this Bulletin, request form for Personnel Service listings.

Positions Open—February—O-13-901. **March**—O-39-904, 41-905, 45-906, 45-907. **April**—O-50-908, 55-909, 58-910, 56-911, 59-912, 71-913. **May**—O-77-914, 49-915, 95-917, 66-918, 97-919. **June**—O-124-920, 131-922, 132-923, 111-924, 133-925, 135-926, 136-927, 137-928, 140-929, 140-930.

Positions Wanted—January—W-355-67, 383-68, 411-69, 412-70, 406-71, 419-72, 422-73. **February**—W-9-1, 17-2, 22-3, 23-4, 20-5. **March**—W-25-6, 33-9, 30-10. **April**—W-54-11, 70-12, 72-13. **May**—W-83-15, 84-16, 67-18, 80-19, 98-20, 99-21, 100-22, 101-23, 102-24. **June**—W-103-25, 104-26, 118-27, 112-28, 123-29.

NEW POSITIONS OPEN

Agricultural Engineering Editor to handle related matters for leading farm paper in Midwest, with emphasis on materials handling, buildings, and machinery. Age 25-35. BSAE. Some writing experience. Farm background, with understanding of how farmers work and think. Personable and able to meet all types of people well. Interest in people and desire to be of service to farmers. Travel about one-third of time. Salary open. O-150-931

Vehicle Development Engineer to conduct evaluation tests, make load analyses of full scale machines, inspect parts after test runs, design test fixtures, set up instrumentation, and submit reports. Midwest. Age up to 35. BS or MSAE. One or more years experience in related work. Expanding company promoting from within. Promotions and increases on merit basis. Salary $520 or more, depending on experience. O-177-932

Agricultural Engineer for design and development in farm power and machinery field with established special equipment manufacturer in West. Will be assigned to complete machine design and development projects, and design of farm machine components. Age 30-40. BSAE or BSME. Experience 5 years in farm machine design and development. Good health. Married. Opportunity for advancement for man with executive ability. Salary open. O-186-933

Agricultural Engineer for research and development in forage and grain handling equipment in conjunction with specialized field storage structures. Engineering work will involve new concepts and new applications of materials for handling crops. Midwest. Large company, well established in farm and industrial equipment fields. Age 26-35. MSAE with research experience in materials handling preferred. BSAE with option in power and machinery considered. Must be creative and have interest required to investigate and develop new and untried theories. Excellent opportunity for advancement. Salary open, in line with experience and ability. O-151-934

NEW POSITIONS WANTED

Agricultural Engineer for development, teaching, sales, or management in power and machinery, rural electric or product processing, with manufacturer or public service. Any location. Willing to travel. Married. Age 36. No disability. MSAE, 1951, Michigan State University. College teaching 2 years. With full line farm equipment manufacturer 7 years. Currently regional manager for large manufacturer of diesel engines and allied equipment. Available on reasonable notice. Salary open. W-154-31

Agricultural Engineer for design, development, research, or management in farm structures with manufacturer or distributor; preferably in eastern United States. Married. Age 28. No disability. BSAE, 1956, University of Vermont. Farm background, with experience in farm building construction. Draftsman experience in military service. Summer work during college vacations in hardware sales and painting. With farmers cooperative since graduation, in training and as assistant chemist in quality control laboratory. Desire to return to farm structures field. Available on one month's notice. Salary open. W-178-32

Agricultural Engineer for research in soil and water, product processing or farm structures with public service or industry. Preference Southwest. Married. Age 44. No disability. BSAE, also BS in general agriculture. Land drainage and water resources work with Louisiana Department of Public Works, 4 years. Registered agricultural engineer in Louisiana. Farm management experience 4 years. Available on one month's notice. Basic (lowest) salary $4,800 per year. W-196-33

Agricultural Engineer for design, development, or research in power and machinery, farm structures, or electric power and processing field with federal agency or industry. Any location. Married. Age 24. No disability. BSAE expected in August, Virginia Polytechnic Institute. Farm background. Army service 2 yr, with training and experience in electronics. Student assistant part time on control of insects with light waves and on special electronic equipment. Available September 5-15. Salary open. W-190-34

Sales Engineering Careers in Foreign Trade

CATERPILLAR TRACTOR CO.

The World's Leader in the field of crawler tractors, motor graders, diesel engines and earthmoving equipment offers:

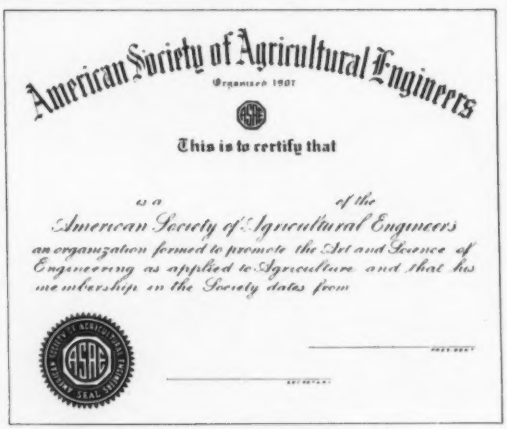
Rewarding Opportunities
to Engineers as
FOREIGN SALES REPRESENTATIVES

- All Recognized Engineering Degrees
- Experience Preferred — Not Essential
- Foreign Language Desirable — Not Necessary

Comprehensive Training Program
World-Wide Foreign Assignment
Liberal Home Leaves
Foreign Service Allowances

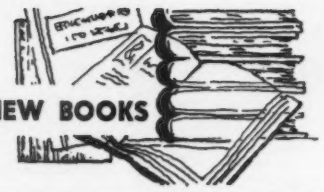
SEND RESUME' TO:
John A. Myers — (AE79)
Technical and Professional Employment
CATERPILLAR TRACTOR CO.
Peoria, Illinois

ASAE Membership Certificate


American Society of Agricultural Engineers
Organized 1907
This is to certify that
of the
American Society of Agricultural Engineers
an organization formed to promote the Art and Science of Engineering as applied to Agriculture and that his membership in the Society dates from

The official ASAE Membership Certificate, available to ASAE members only, measures 10¾ by 14 inches. It is engraved on heavy parchment paper and is suitable for framing. The member's name, grade of membership, and month and year of admission to the Society are engrossed by hand. The certificate is signed by the President and Secretary and bears the official (gold) seal of the Society. The price of the certificate, including engrossing, is $3.00. Order direct from

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS
P.O. Box 229, St. Joseph, Michigan



The London Directory and International Register, 1959 edition. Cloth, gold stamped, 8 x 11 inches, 1500 pages. Published by The London Directory Co., 352-354 Kilburn High Road, London, N.W.6., England. $14.50.

This volume contains information on the world's markets. Each trade classification appears once only, thus obviating laborious search for like sections in numerous parts of the book. It is useful to agents who desire contact with manufacturers and to buying agents for sources of supply. There are nearly 200,000 addresses classified under 5,000 commercial and professional headings, including manufacturers, exporters, importers, manufacturers' agents, forwarders, shippers, bankers, merchants, etc. Also included are special sections for the legal profession, motor car industry, hotels, trade associations, etc. New features are special sections in two colors on art paper for Malta, Czechoslovakia, Hungary and Poland.

A Diderot Pictorial Encyclopedia of Trades and Industry, 1959 edition. In two volumes, cloth, 12¼ x 9 inches. Vol. I contains 207 plates, Vol. II, 485 plates. Published by Dover Publications, Inc., 180 Varick St., New York 14, N. Y. Vol. 1, $10.00. Vol. II, $10.00. Two vol. set, $18.50.

A pictorial review featuring reproduction of copper plates illustrating manufacturing and trade just before the industrial revolution. Major trades are illustrated in sequence, carrying processes through from raw materials to finished product. Volume I contains plates on agriculture and rural arts, arts of war, iron foundry and forge, extractive industries, and metal working. Volume II covers glass, masonry and carpentry, textiles, paper and printing, leather, gold, silver and jewelry, fashion, and miscellaneous trades.

Electrical Safety, by H. W. Swann. Cloth, 9 x 5¾ inches, xii + 292 pages, illustrated and indexed. Published by Philosophical Library, Inc., 15 East 40th St., New York 16, N. Y. $15.00.

Chapters in this book deal with electrical accidents: past, present and future; physical aspects of electricity; the electricity regulations. Applications and exemptions; adequacy, operational working, and maintenance; cables and lines; automatic protection, portable tools and earthing: Regulations 8, 13 and 21; switchboards: Regulations 14 to 18; inflammable surroundings: Regulation 27; static electrification: fire and explosion risks, and domestic electrical installations—some safety aspects.

1959 Year Book, The Tire and Rim Association Inc. Paper, 11 x 8¾ inches, 144 pages. Published by the Tire and Rim Association Inc., 2001 First National Tower, Akron 8, Ohio. $3.50.

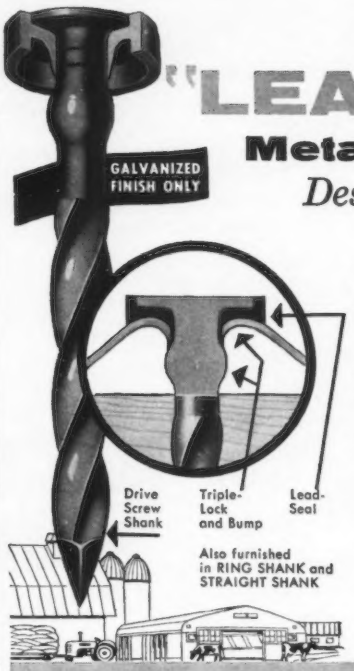
This loose leaf book is plastic tab indexed with the following sections: passenger car, truck-bus, off-the-road, agricultural, industrial, valve, and aircraft. It also contains names and addresses of association members, and names and company affiliations of advisory committee officers.

Heating, Ventilating, Air Conditioning Guide, 1959 edition. Cloth, gold stamped, 8½ x 11 inches, xxiv + 1,051 pages. Published by American Society of Heating and Air-Conditioning Engineers, Inc., 62 Worth St., New York 13, N. Y. $12.00.

This 37th edition contains larger illustrations, working charts and tables including 286 new or revised diagrams and charts. The 768 page technical data section is divided into 12 general sections: fundamentals; environment, comfort, and physiological principles; heating and cooling loads; room heating and cooling methods and equipment; air systems and equipment; steam and water systems and equipment; heat generating methods and equipment; refrigeration, spray apparatus, and sorbents; controls, instruments, and motors; specific applications; industrial systems; and general.

Mechanical Cultivation in India, (English) by D. A. Gadkary. Cloth, 9 x 7½ inches, 143 pages, indexed and illustrated. Published by The Business Manager, Indian Council of Agricultural Research, New Delhi—2.

This publication is the result of a project sponsored by the Indian Council of Agricultural Research in 1952. It is based on extensive investigations into the needs and problems of the farmers in different parts of the country, and deals with such important subjects as scope for mechanical cultivation, farm machinery and implements suitable for different areas, maintenance of machinery, and organizational problems.



DENISTON "LEAD-SEAL"
Metal Roofing Nails
Designed to a Special Job

No one type of nail is good for all types of duty. That's why DENISTON designed a nail especially for use in applying metal roofing. One that would give a seal through which no moisture can penetrate.

DENISTON "Lead-Seal" galvanized metal roofing nails have proven their efficiency because of these advantages—"lead-seal", triple-lock, drive screw shank and heavily zinc-coated for protection against rust. With this combination you get a nail that will easily last the lifetime of a roof. To insure superior quality, DENISTON "Lead-Seal" nails are now available in galvanized finish only.

All DENISTON nails are shipped in 50 lb., 3-ply corrugated colorboard cartons. Descriptive literature will be sent immediately upon request.

DENCO Lead-Head Metal Roofing Nails

6,000 pounds of pressure is used to compress the lead *cold*, both *over* and *under* the steel head of the nail as well as *down the shank*. This insures a tight head that is impossible to knock off when driving the nail. In addition, the lead forms a perfect seal in the hole made by the nail. The heads will not "pop" off from the expansion and contraction of the metal roofing nor from wind vibration.

Bright or Galvanized Finish

32 Years of Quality Nails

THE DENISTON COMPANY

4876 South Western Avenue • Chicago 9, Illinois

IN CANADA: EASTERN STEEL PRODUCTS CO., LTD., PRESTON, ONTARIO

DENISTON Lead-head ROOFING NAILS

Index to Advertisers

Aetna Ball & Roller Bearing Co. 381

Armco Steel Corp. 379

Automotive Gear Div., Eaton Mfg. Co. 372

Bearings Company of America Div., Federal-Mogul-Bower Bearings, Inc. 371

Bower Roller Bearing Div., Federal-Mogul-Bower Bearings, Inc. 383

J. I. Case Co. 377

Caterpillar Tractor Co. 422

Columbian Steel Tank Co. 421

Deere & Company 374, 375

The Deniston Co. 423

Farm Fans, Div. of Ewing Foundry, Inc. 424

Federal-Mogul-Div., Federal-Mogul-Bower Bearings, Inc. 415

H. D. Hume Co. 380

International Harvester Co. 369

Link-Belt Co. ..... 3rd Cover

National Rain Bird Sales & Eng. Corp. 424

National Seal Div., Federal-Mogul-Bower Bearings, Inc. 373

New Departure, Div. General Motors Corp. ..... 2nd Cover

Rockford Clutch Div., Borg-Warner Corp. 418

Rockwell-Standard Corp., Universal Joint Div. 384

Rollway Bearing Co., Inc. 411

Ross Gear & Tool Co., Inc. 409

The Timken Roller Bearing Co. ..... 4th Cover

Twin Disc Clutch Co. 413

United States Steel Corp. 382

Unitcast Corp. 414

West Coast Lumbermen's Assn. 419

Weyerhaeuser Sales Co. 417

Wisconsin Motor Corp. 420

ADVERTISING REPRESENTATIVES

New York 17 — Billingslea and Ficke, 420 Lexington Ave. LExington 2-3667

Chicago 2—Dwight Early and Sons, 100 N. La Salle St. CEntral 6-2184

San Francisco 5 — McDonald-Thompson, 625 Market St. YUkon 6-0647

Los Angeles 5 — McDonald-Thompson, 3727 W. Sixth St. DUnkirk 7-5391

Seattle 4 — McDonald-Thompson, 1008 Western Ave. MA. 3-3766

Portland 1 — McDonald-Thompson, 404 Times Bldg. CApital 2-5146

Denver 3 — McDonald-Thompson, 620 Sherman St. KEystone 4-4669

Houston 6—McDonald-Thompson, 3217 Montrose Blvd. JA. 9-6711

Tulsa 4 — McDonald-Thompson, 2010 South Utica. RIverside 3-1981

Phoenix — McDonald-Thompson, 541 West Claremont. CRestwood 4-1342

There's NO SUBSTITUTE for RAIN BIRD Sprinklers

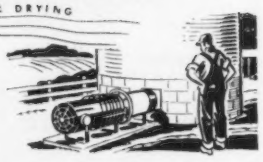
Only Rain Bird irrigation sprinklers have all the advantages that have made them famous the world over. Every Rain Bird sprinkler advancement has been field-tested... and in the field, Rain Birds never have been surpassed. For top yields... top quality... there's no substitute for Rain Bird sprinklers.

There's a world of satisfaction in the performance of Rain Bird Sprinklers. Send for free irrigation engineering data.

NATIONAL RAIN BIRD SALES & ENGINEERING CORP.
Azusa, California
RAINY SPRINKLER SALES
609 West Lake Street, Peoria, Illinois

Consider the advantages of DRYING-IN-STORAGE with AUTO HUMIDITY CONTROL DRY-O-MATION NATURAL DRYING

DRY-O-MATION is drying in storage with supplemental heat added. It's the sure, safe way to accomplish perfect grain conditioning in the bin . . . *automatically* . . . with no handling. DRY-O-MATION saves time and money for the farmer . . . makes him independent of the weather. He can harvest at the most favorable time; he can market when prices are best. DRY-O-MATION eliminates the hazards of fluctuating humidity . . . assures uniform conditioning of every layer of grain with no over-drying. *If you want to learn more about why leading bin manufacturers offer DRY-O-MATION as standard equipment, write us.*



DRY-O-MATION leads in method development and equipment effectiveness with gas burners like this.

Electric, too. This is the new Electri-Con—the unitized automatic electric grain conditioner. Designed for Heat-Air-Power balance; Fire-safe; weather protected.

FARM FANS / DIVISION OF EWING FOUNDRY, INC. 424 S. Pennsylvania St., Indianapolis 25, Ind.

The good name of your machine is LINK-BELT's first consideration . . . TRADE MARK . . . and quality should be your first consideration in the chain you buy

HARRINGTON MFG. CO.'S PEANUT COMBINE is equipped with Link-Belt precision steel roller chain, double pitch "AG" roller chain, screw conveyor and ball bearings for drives and conveyors.

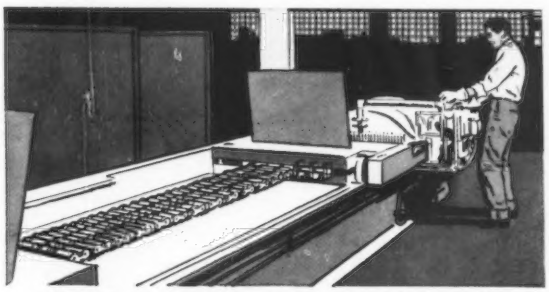
Be sure you specify drive and conveyor chain with

the quality good design deserves

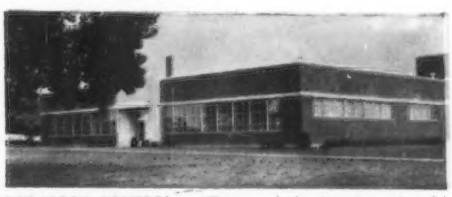
Use LINK-BELT chain . . . built to top farm machine standards as determined by field and lab tests

LINK-BELT's recommendation of the best drive or conveying chain for your machine is based on experience gained in field tests under actual working conditions. And Link-Belt is in the best position to make unbiased proposals because our line of chain, sprockets and attachments is *complete*. Horsepower, loading, speed, impact—every requirement can be met to enable your machine to maintain rated performance and efficiency throughout its life.

Yes, Link-Belt's unmatched facilities, experience and services are your best assurance of quality chain, properly applied. Next time you're considering a drive or conveyor application, our chain specialists will be glad to work with your engineers. For facts and prompt service, call your nearby Link-Belt office.



ACCURATE MANUFACTURE— Modern specialized machines allow the economies of large-scale production. Continuous inspections safeguard tolerance and finish of every link of chain. With these extensive facilities, Link-Belt has ample capacity to meet your production shedules.

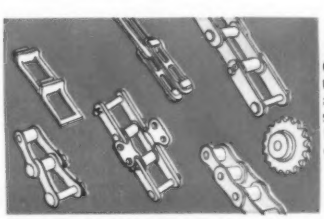


LABORATORY CONTROL —Every chain bearing the Link-Belt trade mark meets rigid uniformity specifications. Our modern laboratory continuously explores new refinements to increase chain life. It is located at the world's largest plant manufacturing drive and conveying chain.

LINK-BELT

15,176

CHAINS AND SPROCKETS

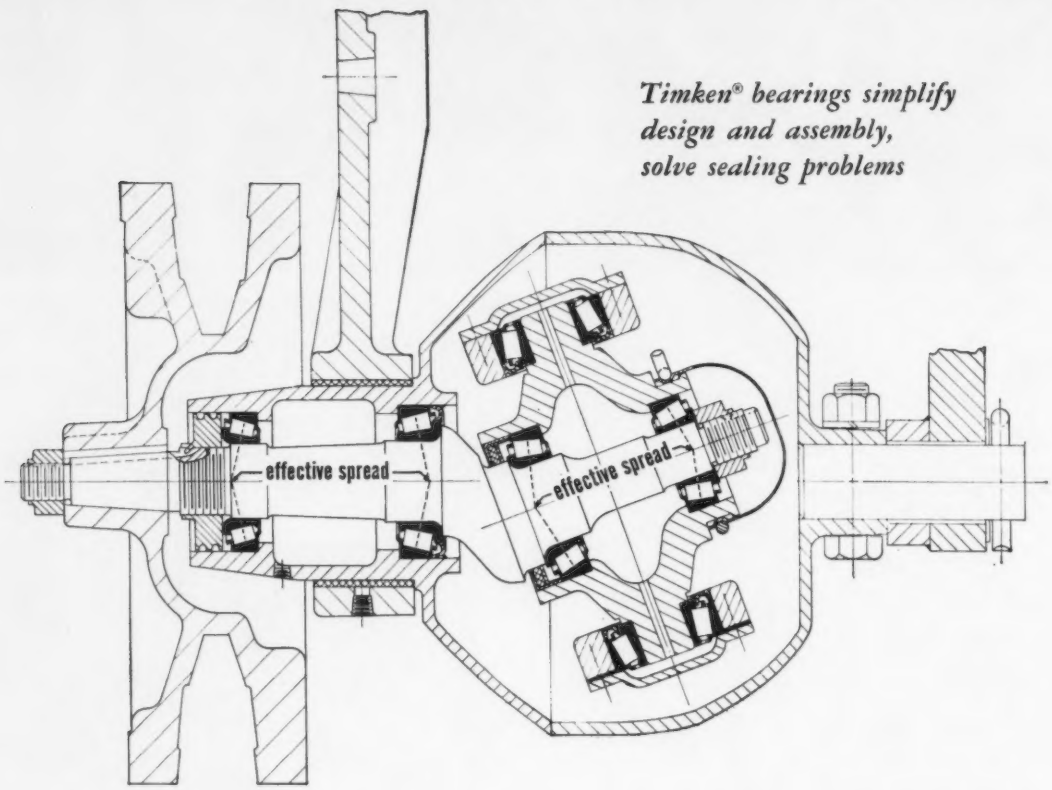


COMPLETE LINE of agricultural chains, sprockets and attachments permits cost-saving specialization — offers the right chain for all conveyors and drive needs.

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World.

New McCormick No. 100 mower uses wrist-action drive to cut vibration, give smoother operation

Timken® bearings simplify design and assembly, solve sealing problems



BY using six of the new standardized, lower cost Timken® tapered roller bearings, International Harvester engineers gained these big advantages in their new Model 100 mower.

1) The "wrist-action" drive reduces vibration, permitting smoother, high-speed operation with longer life. 2) The new Timken bearings are smaller, lighter, yet capacity-packed. They save space and weight, cost less. 3) New Timken "Duo-face" seal bearings permitted the yoke to be made in one piece, improved design and cut costs. The "Duo-face" gives positive 2-way sealing (face and O.D.). And it cuts installation costs because bearing and seal are pre-assembled.

Timken bearing applications are on the wobble shaft, flywheel shaft and oscillating yoke. Also, in the No. 100 trailing model, the transport wheels are equipped with Timken bearings for fast highway transport. IH engineers specified the new design Timken "green light" bearings, made by high-speed mechanization, to simplify design and get high load capacity in a small space. And by permitting indirect mounting of the wrist-action and flywheel shafts, where maximum stability is required, they let engineers take advantage of the effective spread principle of Timken bearings. (see above).

To get smaller, more compact designs, more and more engineers are standardizing on Timken bearings. Their ability to take both radial and thrust loads and full line contact between rollers and races gives Timken bearings extra load-carrying capacity. Their true rolling motion practically eliminates friction, saves power and fuel. And because Timken bearings hold shafts concentric with housings, they make closures more effective in keeping dirt out, lubricant in.

Timken bearings enable agricultural engineers to solve three big problems: 1) combination loads; 2) dirt; 3) ease of operation. Farmers get better, more economical machines. For help in designing new bearing applications, call our Sales Engineers. Send for free brochure, "What Timken Company Sales and Service Engineers Can Do For You". The Timken Roller Bearing Company, Canton, 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ▯ AND THRUST ▭ LOADS OR ANY COMBINATION ✳

The farmer's assurance of better design ☛

Tapered Roller
TIMKEN BEARING
EQUIPPED